An Approach of Applying Abstract Art in Furniture Design for Mass Customization

By

Jialing Mao

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Approved by

Tin-Man Lau, Chair, Professor of Industrial Design

Bartlett, Randall Neal, Professor of Industrial Design

Jerrod Windham, Associate Professor of Industrial Design

Abstract

Although Bauhaus's functionalism is irreplaceable in the history of modern design and the influence has not gone away， with the development of the times, people also have higher aesthetic requirements. It is not difficult to recognize the demand to break the “square box”. In order to meet the aesthetic and psychological needs of users, the Memphis movement began, which strongly opposed functionalism, but the movement ended quickly because it was too radical. We appreciate Memphis' different understanding of beauty, and also respect the rational component of functionalism. In today’s highly commercial society, we emphasized on efficient, short-term optimal solutions, so this thesis will focus on to giving designer a guideline to absorb abstract art as inspirations to design furniture for mass customization, leaving some space for customer express their personal preference.

With new needs and supported environments, it is possible for designers to bring art back to design for furniture industry. This thesis will rationally analyze art from the basic elements of

line, shape, space, texture and composition, define the connotation of art, and process the abstract art in order to design furniture which has good performance and meets the personalized aesthetic needs of users.

Mass social computing opened the doors for innovative partnerships between customers and suppliers. More or less mass customization, mass personalization, and open innovation merged into one field, which we call MC. Supported with configuration tools provided by the supplier, customers are configuring and customizing products to meet their personal needs.

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Chapter 1 Introduction

1.1 Problem Statement

In the era of modern mass production，modernism can be seen as the most powerful theory that has been respected since 1820. Functionalism at that time was anti-decorative, adapted to mass production and standardization of production methods. Although Bauhaus's functionalism is irreplaceable in the history of modern design, since then, people's demands for aesthetics are getting higher, and the voice for breaking the "square box" is getting louder. Bauhaus's functionalism is based on the idea that the square box is theirs believe, which creates the Bauhaus design. The overly rational shortcomings in the long-term vision of Bauhaus design are: neglecting the aesthetics of products and neglecting the spiritual pleasure of people when using products; too monotonous of a design gives people a feeling of desertion and grayness, and makes people's emotions without release, which all these indicate that the reform of Bauhaus

functionalism has become a trend. Pure functionalism cannot meet user's expectations of the product today.

The furniture industry needs some fresh blood to come from abstract art, which can greatly express emotion and personality visually. Mass customization makes it possible for customers express their personalities and different needs at affordable prices.

Why emotion and personality important?

We do not lack a desk or a chair. There are tons of furniture in the market. Why do we need to design more furniture? How can we design new furniture to distinguish it from existing products? How can we catch people's eyes and make our products competitive?

Attractive things work better (Norman, 2004, p. 17) so a different and attractive appearance can more easily evoke people's positive emotion and influence people's judgement, thus, making the products more desirable. That is, the products that people really want and desire, will sell. Then, there will be an era when products are made to make people feel good and express their personality (Lokman, 2003, p. 3).

How Mass customization can help?

For more than 100 years the concept of mass production has been at the core of industrial development. The advantages of mass production are obvious: bring high quality of products with lower production costs. But also, mass production creates highly standardized products with low potential for individualization. Although the first concepts of mass customization (MC) aimed at balancing benefits from mass production and individualization appeared in 1899 in France (Piller, 2006, p. 698). MC did not reach the masses until effortless and cheap communication and collaboration tools became available. Social computing opened the doors for innovative partnerships between customers and suppliers. Thus, mass customization makes customized goods affordable and everyone can find exactly what they want without being lost in an overwhelming and giddy market.

Why abstract art?

-Unique

Abstractionists use a visual language of shape, form, color and line to create a composition which may exist with a degree of independence from visual references in the world

(L. Milroy, 1982; M. Milroy, 1986). It inspires our curiosity about the reaches of our imagination and the potential for us to create something completely unique in the world.

-=

Abstract Art is not only visually-creative “Abstraction allows man to see with his mind what he cannot see physically with his eyes”-Arshile Gorky (Nimmer, n.d.).

-Abstract enough to evoke universal and unique understanding

Abstract art expresses certain feelings and emotions by creating an entire environment for the viewer to walk into or observe from afar. Non-objective painting is possible to allows viewers to bring their own experiences. This art has a mysterious language that is somehow both deeply personal and universal (Nimmer, n.d.).

Why furniture design?

If we understand furniture as objects of applied arts intended for mobile and permanent furnishing of residential interiors. (Smardzewski, 2015, p. 47), furniture fulfils two main functions: being usable and ensuring comfortable relaxation, recreation, sleep, etc., and aesthetics connected with enriching the decor of the room.

1.2 Need for Study

The individual is "an integral part of the entire vast social and cultural system, a small, relatively less important component, and the social and cultural system, in any age, even in the distant era, contains many individuals. " (White, 1949). The free development of everyone is the condition for the free development of all people. Obviously, although the individual seems to be minimal to the entire macro human history, the pursuit of individuality (the individual's free and comprehensive development) and the overall harmonious development are not conflicting, but complement each other and are mutually conditional. Individuals exist for society and society exists for individuals. Without the self-contribution of infinite individuals, culture loses its carrier, aesthetics loses its subject, and history is meaningless (Jia, 2008). As designer we should take individual needs seriously.

For designer

While a major motivation for a designer is ‘the need to create’， this need is shaped by many personal qualities， skills and abilities. Designers, like everyone else, possess

artistic，creative and practical skills，mixing intuitive and analytical approaches and linear and iterative processes in a search for originality .

Study of art is a great way to build artistic skills and bring more creative ideas to design.

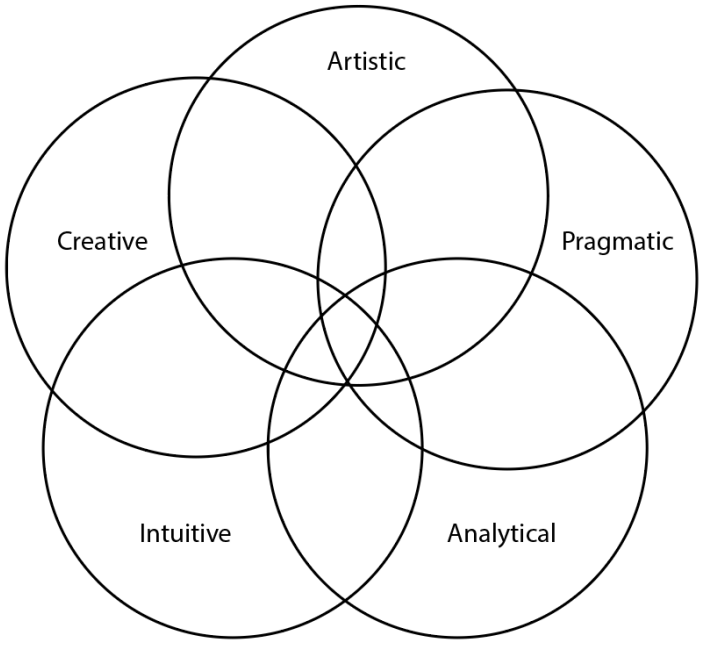


Figure1. 1

Different skills of designers (Boyle, 2003)

1.2 Objective of Study

- To study and define abstraction

- To study the abstract art genre

- To study the relationship between abstract art and furniture design

- To study how to analyze abstract art

- To define and study modular furniture design

- To study mass customization

- To develop an approach of using abstract art as inspiration to design furniture for mass customization.

1.4 Definition of Terms

Furniture: If we understand furniture as objects of applied arts intended for mobile and permanent furnishing of residential interiors, furniture fulfils two main functions: usability and, ensuring comfortable relaxation, recreation, sleep, etc., and aesthetics connected with enriching the decor of the room (Smardzewski, 2015, p. 47).

Abstract art: The concept of a particular style/genre using.

Mass customization: Mass customization refers to a customer co-design process of products and services which meets the needs of each individual customer with regard to certain product features.

1.5 Assumptions of Study

It is assumed that all the research, approaches, methods and data I found are correct.

It is assumed that some users like abstract art and would find value in furniture inspired by this art.

1.6 Scope and Limitations

It is hard to guarantee that the abstract print version of abstract arts are the right colors. And the school is located in Alabama, which has a limited number of abstract art museums, making it hard analyze the original work.

Abstract art is described as nonobjective –literally "against the object." Therefore, the biggest problem is going to be transforming two-dimensional paintings to three-dimensional functional furniture.

Scope - extent of the research

This thesis will only focus on paintings, excluding performance art and sculptures. In this genre, the author will only focus on western art movements, influential schools, and iconic artists.

Furniture design will be limited to bedroom and living room furniture design, which are more suited to artistic furniture.

1.7 Procedures and Methodology

Procedure 1: Study and define abstract art.

• Studying research, dictionaries, articles and library resources

• Sorting and analyzing research

Procedure 2: Study the different genres of abstract art

• Studying research, dictionaries, articles and library resources

• Analyzing existing abstract art

Procedure 3: Study the theories reading how to analyze abstract art

• Studying research, dictionaries, articles and the spirit of art

• Sorting and analyzing researches.

• Concluding a way to breaking down abstract art as inspirations for furniture design.

Procedure 4: Study Luc Peire art as case study of analysis abstract art tool

• Collect art

• Analyze art

Procedure 5: Summarize the relationship between furniture design and abstract art

• Studying online research, dictionaries, articles and library resources

• Analyzing and illustrating relationships

Procedure 6: Develop the design flow of mass customization furniture using abstract art as inspiration.

Procedure 7: Apply the approach into a mass customization furniture design process.

1.8 Anticipated Outcomes

The primary outcome is to help designers to design artistic furniture for mass customization. The thesis will develop a way to analyze any genre of abstract art to service furniture design. The artistic furniture is not one individual art piece but can be mass customized.

Chapter 2 Literature Review

2.1 Abstract art

This chapter will focus on defining abstraction, abstract art, the relationship between furniture design and abstract art and the way to analyze abstract art. Once we have a clear idea about the abstract and the process of abstraction, we can have a better understanding of abstract art and then have a way to break down abstract art as visual elements to furniture design. Since in the product design history, there were already some designers tried to apply art into furniture design that we can reasons for their success feature and failures.

2.1.1 What is Abstract

The term "abstraction" in art and design can be traced back to the beginning of ancient human graffiti and creation activities. Generally, the definition of "abstract" is "the concept of extracting common features from most things and synthesizing them" (China encyclopedia - philosophy, 1987).

2.1.1.1 Etymology meaning

The word abstract, derived from Greek philosophical nouns, was adapted by Aristotle. The word "abstract" in English comes from Middle English abstract, borrowed from Latin abstractus, perfect passive participle of abstrahō (“draw away”), formed from abs- (“away”) + trahō (“to pull, draw”). The verbal sense is first attested in 1542. In the Merriam-Webster dictionary, the meaning of the abstract word source is "drawn away from", that is, "taken away from something" (ODE, 2019).

2.1.1.2 Modem meaning

There are two main definitions for "abstract" today: (1) disassociated from any specific instance; (2) extracting a quality apart from an object (Arnheim,1947).

What a creator observes may be the part that attracts his or her attention, so the creation will convey the original message he observed in a typical "partial" instead of "whole." The creator must learn abstraction. The important part of the process is to retain the original message. In the fields of philosophy, science, psychology, etc., there are similar phenomena. The "abstract model" in Figure 2.1 illustrates: extracting the "element" from the original shape. Or "Relation", which enables the extracted part to represent the original thing, that is, the abstracted form can replace the original form.

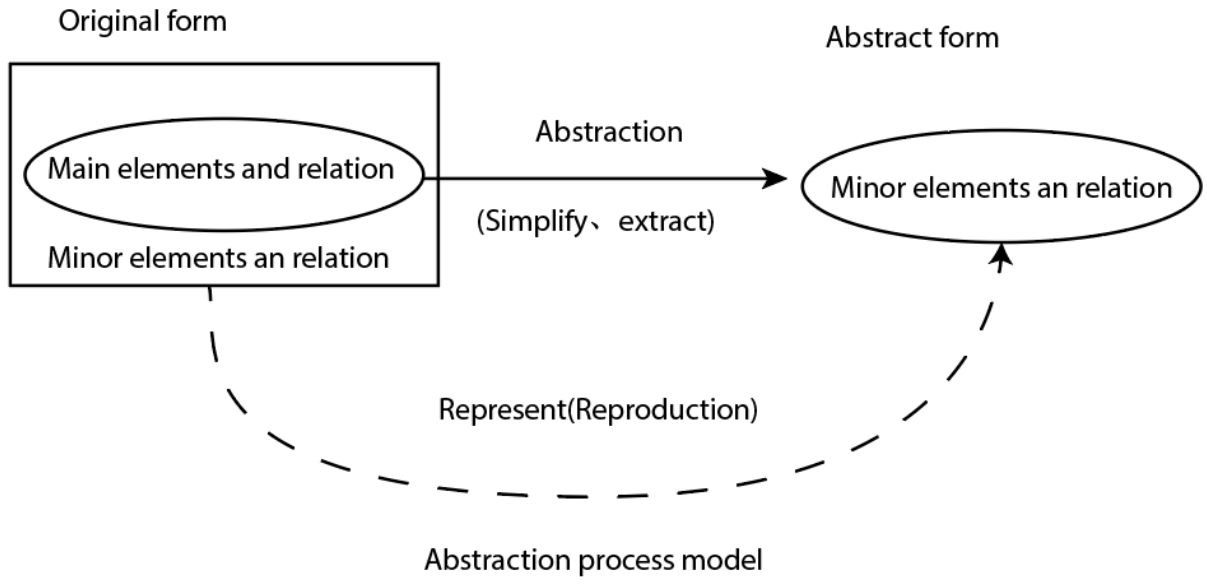


Figure 2. 1

Abstraction process model (Wang, 1994, p.83; Arnheim, 1947)

2.1.1.3 Difference between "Abstraction", "simplification" and "symbolization"

The words "abstraction", "simplification" and "symbolization" are often mixed, because the three have overlapping meanings. The more significant differences between the three are organized as follows:

First, the term "abstraction" refers to the process of extracting spirit from something or partially representing the whole, so abstraction is not just a "simplification" of outlines (Arnheim R. , 1969). It also includes extraction in essence and meaning.

Second, in Gestalt psychology, the term "simplification" refers to the "best shape", which is a structure and form that exhibits maximum energy at maximum intensity in a concise, clear form. Therefore, the discussion of simplification of "shape" is simplified.

Third, "symbolization" refers to the conveyance of abstract meaning through a meaningful medium. This "meaningful medium" refers to the symbol, but the meaning and the symbol do not necessarily show the direct relationship, sometimes it is customary (Arnheim, 1966); and "symbolization" refers to the process of forming symbols.

2.1.1.4 The difference between abstract form and abstract art

“Abstract form" is the concept of "formal techniques;” “Abstract art” is the concept of "special style genre". The "abstract form" referred to in art/design begins with the stone carvings of the Neolithic Age and runs through the entire art/design history; however, as a "genre" of abstract ideas, it begins with the Picasso in the early 20th century (Picasso) and the development of the Braque cubism (Osborne, 1979).

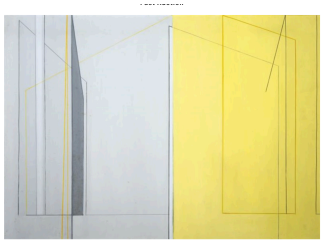
Broad sense	Abstract form	The concept of expression (starting with the original graffiti)	Artificially processed graphics For example （Figure2.2）: cave paintings, auspicious patterns, graphic designs, etc.	Figure2. 2 Earthenware bowl with antelope design, from Hassuna near Iraq · 5000 B.C  (Jaffe, 1967)
Narrow sense	Abstract art	The concept of a particular style genre	Refers to the work of abstract art. For example （Figure2.3）: the creations of Kandinsky, Mondrian, Malevich, etc.	Luc Peire Tour d'Ivoire, 1963 Figure2. 3 

Table 2. 1

Definition of "abstract" in broad and narrow sense in art/design (Wang,1994)

In the West, art/design abstraction has two development directions:

(1) simplifying the concrete content seen by nature into an abstract shape;

(2) using color, lines, patterns or textures to make the creation based on abstract in the beginning.

The development of abstract art can be divided into two major schools:

(1) geometric abstraction (or cold abstraction): based on Cezanne's theory, developed through cubism, constructivism, and new form. It is characterized by a geometric tendency to use Mondrian as a representative of the faction.

(2) Lyric abstraction (or thermal abstraction): starting from the artistic concept of Gauguin, developed by Fauvism and Expressionism, with a romantic tendency to Kandinsky which is the most representative artist of this genre(Wang,1994).

2.1.1.5 Abstract art development process

Any artist cannot exactly represent the nature， so if the result of simplification is abstraction， then in wider sense any painting is abstract. According to Ocvirk et al (2002), he concludes there are four stage of abstract development (Table2.3)(Ocvirk, Wigg, Bone & Cayton, 2002)

<table>
<tr><td>Naturalism</td><td colspan="2">Fully apparent (very objective and specific)</td></tr>
<tr><td>Realism</td><td colspan="2">Representation, but emphasizes emotional aspects (more subjective)</td></tr>
<tr><td>Semi-abstract</td><td colspan="2">Partial representation, but simplified and rescheduled</td></tr>
<tr><td rowspan="2">Abstract</td><td>Objective</td><td>Non-objective</td></tr>
<tr><td>Subjective basis,
But it seems visually
Can't see the specific thing</td><td>Non-representative, does not mention
any figurative subject, and believes that
the artistic value is completely in the form
and content.</td></tr>
</table>

Table 2. 2

(1) The Naturalism stage refers to the description of nature and the avoidance of the subjectivity effect.

(2) The Realism stage is a slightly modified presentation after the creator feels the subject.

(3) The appearance of the semi-abstract phase is less “natural” and begins to be significantly simplified and reorganized with less recognition.

(4) The abstract stage is a non-figurative appearance, or natural objects that have been simplified and reorganized.

Meyer Laveson (Osborne,1976) explores the abstraction process from the perspective of human graphic design. He transform the actual object into five categories of visual representation, called the five degrees of style, that are from the actual object.

To the five gradual stages of abstraction (Figure 2.5): (1) natural photography; (2) pictorial illustration; (3) graphic rendering; (4) Graphic symbology; (5) abstract symbology.

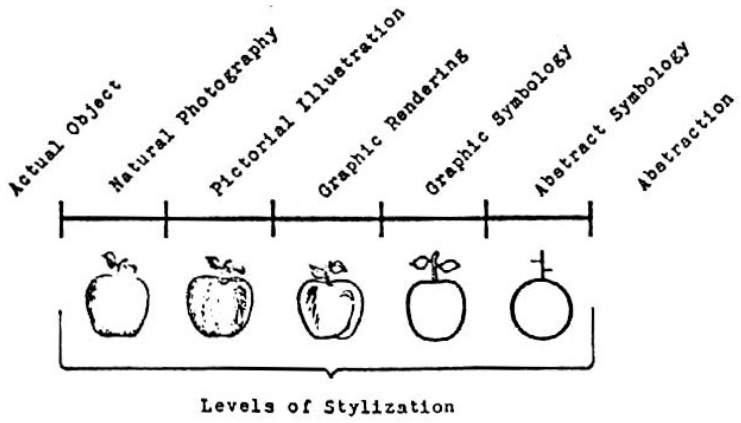


Figure 2. 4

(Osborne,1976)

2.2 Abstract art and design history

This section will focus on the specific art genres in the western art history, starting with impressionism which define the origin of abstract art. The point is to generally have a big image of the abstract arts, to understand the characters, techniques, and influence of art. Then, this study will help designers to position and analyze different artists' work.

2.2.1 Abstract art history

There are three main stage of abstract art history origins and precursor movements, the greatest abstract movements, diverse abstract art. The following figure shows the main abstract art movements in western history.

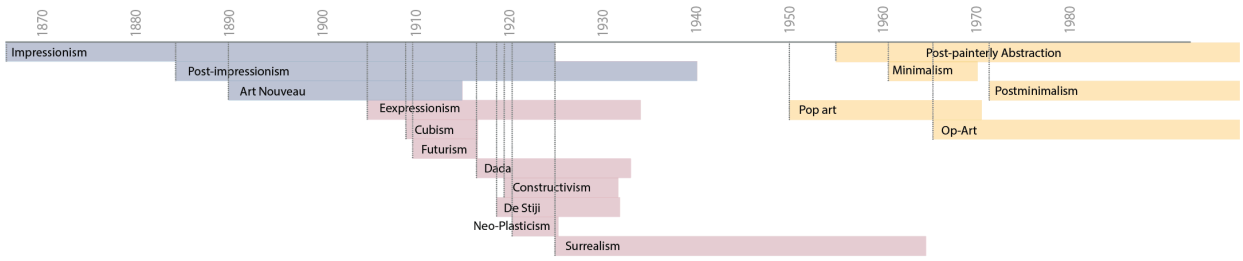


Figure 2. 5

Abstract art history

2.2.1.1 Impressionism (1870-1925)

Impressionism is a style of painting that originated in France about 1870.Painting of causal subjects, often executed outdoors, used divided brush strokes to capture the mood of a particular moment as defined by the transitory effects of light and color (Voytkova, 2016, p. 14).

2.2.1.1.1 Subjects of Impressionist Paintings

1. Scenes from Everyday Life

Unlike traditional painters who focused on portraying dramatic, often historical scenes of idealized beauty religious and or moral meaning, the Impressionists chose ordinary scenes from everyday life as the subject matter of their work. They put emphasis on capturing reality and depicting what they saw at a given moment (Voytkova, 2016, p. 15).

Impressionist artists were interested in portraying people in everyday**,** informal situations: the middle-class during leisure time activities in parks, gardens, or at the seaside, and workmen or rural people at work.

2. Nature

In painting landscapes, the Impressionists tried to put on canvas what they saw in front of them, without idealization. They often made a seemingly ordinary part of nature (a riverside path, a field of haystacks) the focal point of their work.

3. Still Life

Painting still life allowed the Impressionists to experiment with the depiction of changing light and to study the effects of light and shadow on the look of ordinary objects (Voytkova, 2016, p. 16).

We still can see subjects in impressionist paintings，while the point is no longer to depict things themselves, but to capture light, shadow, color and emotion.

2.2.1.1.2 Impressionist Technique

The Impressionists distanced themselves from the somber tones of earlier paintings. They generally refused to use black and earth colors and instead used light, vibrant colors to give their paintings luminosity and to capture the changing effect of sunlight on the scenes they painted. Bright, contrasting colors were put onto the canvas one next to or on top of each other, often without prior mixing or subsequent blending (Voytkova, 2016, p. 17).

- **Brush Work**

In order to convey the essence of the movements and changes of the passing moment, Impressionists used fast, broken brushstrokes without any further smoothing. This method allows the viewer to clearly see the traces of the brush and make the impressionist painting have an unfinished appearance (Voytkova, 2016, p. 17).

- **Painting location**

Impressionist painters often worked outdoors, not in the studio, in close contact with nature, and could directly observe the effects of sun, weather and movement changes.

2.2.1.2 Post-Impressionism (1886-1941)

Post-impressionists were not interested in recording light and color phenomena, post-impressionism is characterized by bright colors, sharp, and usually contoured edges. Like many other forms of artistic expression, these artists try to reveal something of themselves. They use their talents to convey the truth they find about themselves and the words around them.

The post-impressionists were a group of eclectic individuals, so there was no extensive and unified character. Each artist uses an aspect of Impressionism and exaggerates it.

Main painters include Paul Gauguin, Paul Cezanne, Vincent van Gogh, Henri de Toulouse-Lautrec and Henri Rousseau. Cezanne adopted a rigorous classical approach to plein-air painting（Plein air is the act of painting outdoors.）; Gauguin used rich colors but preferred indoor studio painting; Van Gogh painted outdoors but more to express his inner emotions than capture nature; while Toulouse-Lautrec specialized in indoor genre scenes.

> It has been credited with being the foundation of later styles such as Fauvism, Neo-impressionism and Cubism. It stands as a standard of artist self-expression, conveying emotion, embracing your environment and questioning the human condition. (Voytkova, 2016, p. 26)

2.2.1.3 Art Nouveau (1890-1914)

Art Nouveau is an important precursor because of its style of decorative abstraction.

The Art Nouveau style originated in the Arts and Crafts Movement in Britain (notably the designs of William Morris) - also influenced by Celtic and Japanese designs - and was popularized by the 1900 Exposition Universelle in Paris .

The Art Nouveau is highly decorative style of design art , Art Nouveau was characterized by intricate flowing patterns of sinuous **asymmetrical lines, based on plant-forms**. Leaf and tendril motifs are popular Art Nouveau designs, as are female silhouettes and forms (Collins, n.d.).

2.2.1.4 Expressionism 1905-1933

Expressionism is a style whose purpose is to depict an interpretation of a scene rather than simply replicate its true-life features. Expressionist artists distort and exaggerate the emotional effects of reality. The term usually means emotional angst (anxiety). The expressionist attempts to portray not the objective reality, but the subjective emotions and reactions that the object and event arouse in him. He or she achieves his goals through distortion, exaggeration, primitivism and fantasy, as well as the vivid, stimulating, violent or dynamic application of formal elements.

Unlike impressionism, its goals were not to reproduce the impression suggested by the surrounding world, but strongly emphasize the artist's own sensibility to the world's representation.

The expressionist artist substitutes to the visual object reality his own image of this object, which he believes is an accurate representation of its real meaning. The pursuit of harmony and forms is not as important as trying to achieve the highest expression intensity, whether it is from the aesthetic point of view or human critics idea (Voytkova, 2016, p. 62).

The Greatest Abstract Movements

2.2.1.5 Cubism (1908-1914)

Cubism was the first "abstract" art style (Voytkova, 2016, p. 46). Cubists tried to create a new way of seeing things in art. Many of their subjects were represented as

combinations of basic geometric shapes-sometimes showing multiple viewpoints of particular image. This approach was related more to how we see images in our minds-eye rather than in real life; that is if we close our eyes and try to see an image, perhaps of a friend or a family member, it is often difficult to visualize the entire image-we usually see parts or fractured pieces. Therefore， Cubist pictures are often described as looking like pieces of fractured glass (Voytkova, 2016).

At that time some artists became interested in African and Native American art. The styles of those cultures inspired cubism (Jessica, 2008). Cubism is full of geometric angles and shapes, and the picture itself is flattened almost to the point of two-dimensionality. The piece will usually have a tangible sense of movement.

Key Techniques

- Simplification

Subjects are generally reduced to simpler versions built from straight lines, cubes, circles, or cones.

- Fracturing

Simplified outlines of the subject are broken up so that only partial views of each element are visible.

- Recombination

Elements are recombined so that multiple viewpoints are melded together to form a single image in which the viewer can move smoothly from one outline to the next. Cubist painters tried a number of different approaches to this, including the suggestion of translucency of the elements.

- Time

The ability to show multiple viewpoints also allowed for viewpoints from different times.

2.2.1.6 Futurism (1909-1914)

Futurism is an avant-garde art movement that developed in Italy in the early 20th century. Artists sought to inject modern art with vitality, energy, violence and motion of the machine world.

Another important aspect of futurism was the new perception that everything in the world is connected and mixed. They wanted to break the boundaries between things which kept them too separated. Futurism exalted the dynamism of the modern world, especially its science and technology (What is Futurism art, n.d.). The futurists and flouted conventional aesthetic and cultural values by producing works marked by nonsense，travesty，and incongruity. The Futurist painters were searching for new visual approaches to express the typical character of modern time，especially in the modern city.

Futurist painters wanted to pull the spectator on the painting, you could say. They didn't accept the distance between the art and the spectator any more, and this was their vivid criticism of Cubism. The Futurist wanted to push the spectator to move (Voytkova, 2016, p. 52).

2.2.1.7 Suprematism(1913-18)

Suprematism was a Russian abstract art movement, founded by the painter Kasimir Malevich (1878-1935) around 1915, which concerned itself with elementary geometric forms (squares, circles). Kasimir Malevich was the first great pioneer of non-objective art based exclusively on geometric abstraction (Collins, n.d.).

2.2.1.8 Dada(1916-1932)

Dadaism was founded by Hans Arp in Zurich. Dadaism was an expression against the degeneratin in the society and war. The term Dada (from French‘dada’-baby talk horsie)，indicated the loss of meaning in the existing culture.

Generally, Dadaism stood for the opposite of what the society in general stood for. Where art was considered to be aesthetic form of expression, Dadaism ignored aesthetics; “the movement embraced the irrational and nonsensical in an exuberant and highly experimental fashion” (Collins, n.d.)

Many of artists in the Dada period believed that European art was corrupted tried to purify it by mocking it. Therefore, many Dada pieces are extremely playful and teasing.
The artists of the Dada movement had become disillusioned by art, art history and history in general. Many of them were veterans of the First World War and had grown cynical of humanity after seeing what people could do to each other on the battlefields of Europe. Thus they were attracted by the nihilistic view of the world (they thought that nothing mankind had achieved was worthwhile, not even art），and created art in which chance and randomness formed the basis of creation. The basis of Dada is nonsense (Voytkova, 2016, p. 79).

Key characteristics of Dada

- Irrationality

Poetry, performances, and artworks that deliberately undermine common sense challenged the rational underpinnings of bourgeois culture.

- Spontaneity

Artworks and events embraced spontaneous behavior and extemporaneous outpourings.

- Novelty

New experimental forms, such as ready-mades, photomontage, and multimedia, emerged from a willingness to accept anything as art.

- Humor

Dadaist poetry and commentary adopted humor and a sense of the absurd to ridicule and undermine prevailing cultural values.

2.2.1.9 Constructivism (1916-1932)

Semi-politics, Semi-aesthetics, or what we now call the Soviet constructivist style is an art, design and architectural movement that began in Russia in 1914, and it favors applied art (design, architecture) with social purpose rather than "art for art's sake," and which (not unlike Futurism) exalted the "machine" as the source of universal progress. Founded by Vladimir Tatlin, the leading members of this design movement included Alexander Rodchenko, Lyubov Popova, and El Lissitzky. Constructivism combined the dynamism of Futurism and the geometry of Cubism. In its content and aims, Constructivism has great influence among progressive artists and designers throughout Europe, including architects like Le Corbusier (1887-1965) (Collins, unknown) influencing major design trends such as the Bauhaus and De Stijl movements.

Constructivists believe just like music is patterns of sound, abstract art is harmony of patterns and rhythms of color, form and line.

2.2.1.10 De Stijl (1917-1931)

A Dutch art and design group founded by Theo van Doesburg, its leading members included Piet Mondrian, Bart van der Leck, Georges Vantongerloo and Friedrich Vordemberge-Gildewart. To begin with, De Stijl advocated Mondrian's austere artistic theory of geometric abstraction, known as Neo-Plasticism, before adopting a more relaxed system

known as Elementarism. Theo Van Doesburg later became the first to use the term Concrete Art. He also founded the group Abstraction-Creation(Collins,n.d.).

2.2.1.11 Neo-Plasticism (1918-1926)

Neo-Plasticism is a term used to describe the style of painting invented by Piet Mondrian. It comes from the Dutch words "Nieuwe Beelding", used by Mondrian in his articles in De Stijl magazine (1917-19), and in his book "Neo-Plasticism," from 1921 onwards to describe his own type of abstract art. Essentially it means "new art", since sculpture and certain types of painting are considered 'plastic arts'. However, the German version "Neue Gestaltung" (new forming) captures Mondrian's meaning best. He used the name to advocate a 'new forming' in the widest sense, as well as his own ideas and images. In his long essay "Neo-Plasticism in Pictorial Art," Mondrian (1930) wrote: "The new plastic idea should find its expression in the abstraction of form and color, that is to say, in the straight line and the clearly defined primary color." Thus, in a sense Neo-Plasticism was an ideal form of painting, which used only pure color, line and form. In addition to insisting only on primary colors (or non-colors), it advocated solely squares, rectangles, and straight horizontal or vertical lines (Collins, n.d.).

General principle of Neo-Plasticism

1. The plastic medium should be a flat plane or the rectangular prism in primary colors (red, blue and yellow) and in non-color (white, black and gray).
2. There must be an equivalence of plastic means. Different in size and color, they should nevertheless have equal value. In general, equilibrium involves a large uncolored surface or an empty space, and a rather small colored surface or space filled with matter.
3. Abiding equilibrium is achieved through opposition and expressed by the straight line （limit of the plastic means） in its principal opposition, ie, the right angle.

4. The equilibrium that neutralizes and annihilates the plastic means is achieved through the proportions within which the plastic is placed, and which create the living rhythm. (Seuphor, 2015, p. 126)

2.2.1.12 Surrealism (1924-1966)

Surrealism attempted to express the workings of the subconscious by fantastic imagery and incongruous juxtaposition of subject matter. Surrealism was a means of reuniting conscious and unconscious realms of experience so completely that the world of dream and fantasy would be associated with the everyday rational word in “an absolute reality, a surreal.” With its emphasis on content and free form, Surrealism provided a major alternative to the contemporary, highly formalistic Cubist movement and was largely responsible for perpetuating in modern painting the traditional emphasis on content.

> André Breton defined Surrealism as "psychic automatism in its pure state, by which one proposes to express - verbally, by means of the written word, or in any other manner - the actual functioning of thought." What Breton is proposing is that artists bypass reason and rationality by accessing their unconscious mind. In practice, these techniques became known as automatism or automatic writing, which allowed artists to forgo conscious thought and embrace chance when creating art. (The Art Story, 2019)

Freud legitimized the importance of dreams and the unconscious as valid revelations of human emotion and desires; his exposure of the complex and repressed inner worlds of sexuality, desire, and violence provided a theoretical basis for much of Surrealism.

2.2.1.13 Neo-Expressionism (Post -painterly Abstraction) (1955-1965)

The phrase “post – painterly abstraction” was first used in 1964 by the art critic Clement Greenberg (1909-1994), who was the most influential critic and apologist of the new

movement. Greenberg borrowed the word “painterly” from the German art historian Heinrich Wölfflin (1864-1945), who employed it in his book Principles of Art History, to mean “the blurred, broken, loose definition of color and contour” (Wölfflin, 1932).

Umbrella Term for Numerous Individual Styles

In an article for the exhibition catalogue, Greenberg discussed a number of differing styles and tendencies in contemporary American art. In particular, he distinguished the style he called Painterly Abstraction (often called abstract expressionism) from several different styles that followed- which he dubbed Post-Painterly Abstraction. As a general rule, the new abstract painters rejected the emotionalism of Abstract Expressionism, and also its expressive gestural brushwork, in favor of cooler, more anonymous styles of painting (O'Brian, 1993).

Greenberg himself described post-painterly abstraction as being typically linear in design, bright in color, devoid of detail and incident, and inclined to draw the eye beyond the limits of the canvas. Above all it was anonymous in execution, reflecting the painter’s desire to abandon the drama and emotionalism of the older forms of abstract expressionism (O'Brian, 1993).

Contemporary art trend

Greenberg himself was a formalist: he believed that the formal qualities of a painting (line, shape, color) are primary, whereas its emotional, representational, ethical or social aspects are secondary, even redundant. Because post-painterly abstractionists tended to avoid emotionalism, and followed a more anonymous, non-subjective aesthetic, they clearly shared the same view of the primacy of formal elements (O'Brian, 1993).

The styles embraced by this term include Hard-Edge Painting, Color Stain Painting，Systemic Painting; Lyrical Abstraction ,Color Field Painting, and Minimal Painting (Collins, n.d.)

The main component styles

2.2.1.13.1 Action Painting

Action Painting is a highly-charged, impulsive style of abstract gestural painting during which paint is energetically splashed, spilt or dribbled onto the canvas, usually placed face-up on the floor. Although this type of automatic painting has been used by different artists involved in different movements, such as Surrealism, it is mainly related to The New York School of American Abstract Expressionism of the 1940s and 1950s, and associated with the painter Jackson Pollock (1912-56), dubbed "Jack the Dripper." When it first emerged, it was regarded as one of the most revolutionary events in American art (Collins, n.d.).

2.2.1.13.2 Gestural Painting

The term "gestural painting", also known as "gesturalism", is a method used to describe fine art painting characterized by energetic, expressive brushstrokes deliberately emphasizing the sweep of the painter's arm or the hand movements. In other words, the brushwork in a gestures painting expresses the artist's emotions and personality just like a person's gestures reflect their feelings in everyday life. Gesturalism also emphasizes the physical act of painting itself, drawing attention to the "process of creating"(Collins, n.d.).

2.2.1.13.3 Color Field Painting

Celebrated the joys of pure color

The term "Color Field painting" refers to a particular style of American Abstract Expressionism, associated with the New York School of modern art. Created by Clyfford Still

(1904-80), Barnett Newman (1905-70) and Mark Rothko (1903-70), this abstract art was characterized by large fields of flat, solid color, which enveloped the spectator when seen at close quarters. It deliberately avoided depicting forms standing out against a background. Instead, form and background and ground are one, and the picture, seen as a field, rather than a window, draws the eye beyond the edges of the canvas. The style was designed above all to have an emotional impact on the viewer.

During the late 1950s, a second generation of American expressionists, including the abstract painters Helen Frankenthaler (b.1928), Morris Louis (1912-62), Kenneth Noland (b.1924) and Jules Olitski (1922-2007), developed a more impersonal, more formalist style of Color Field, devoid of all emotional and spiritual elements. This method was one of several reinterpretations of Abstract Expressionism, which were given the name Post Painterly Abstraction, by the art critic Clement Greenberg (1909-94), and showcased in a 1964 exhibition at the Los Angeles County Museum of Art(Collins, n.d.).

2.2.1.13.4 Hard-Edge Painting

This mini-movement of American art was a sub-variant of Post-Painterly Abstraction. Hard-edge painting was first used in 1959 by the art historian and critic Jules Langsner, when describing the non-figurative pictures of four West Coast artists (Karl Benjamin, Lorser Feitelson, Frederick Hammersley and John McLaughlin) whom he had brought together in an exhibition entitled Four Abstract Classicists, at the Los Angeles County Museum of Art(Collins, n.d.).

2.2.1.14 Minimalism (1960s- 1970s)

Emerging in a coherent form in New York, during the 1960s, Minimal art, popularly known as Minimalism - but also sometimes referred to as ABC art, Cool art, Literalist art, Object

art, and Primary Structure art - was a major movement of postmodernist art, specifically a style of abstract painting or sculpture characterized by extreme simplicity of form: in effect a type of visual art reduced to the essentials of geometric abstraction (Voytkova, 2016).

Minimalist paintings and sculptures usually include precise, hard-edged, geometric forms, with rigid planes of color pigment - typically utilizing cool hues or maybe just one color. They tend to consist of non-hierarchical, geometrically regular compositions, often arranged in a grid format and made from industrial materials.

2.2.1.15 Postminimalism (1960s-)

Post-Minimalism describes attempts to go beyond the idiom of minimalism, in architecture or the visual arts. In simple terms, 1960s minimalism is a rather intellectual style of art characterized by extreme simplicity of form and a deliberate lack of expressive content. Minimalist artists were only interested in presenting a pure "idea". In Post-Minimalism (1971 onwards), the focus shifts from the purity of the idea, to HOW it is conveyed (Post-minimalism, 2019).

2.2.1.16 Op-Art (1960s-)

In October of 1964, in an article describing this new style of art, Time Magazine coined the phrase “Optical Art” (or “Op Art,” as it’s more commonly known). The term references the fact that Op art is comprised of illusion, and often appears-to the human eye – to be moving or breathing due to its precise, mathematically – based composition (Movement-op-art,2019).

Op art represents a great deal of math，planning and technical skill，as none of it came freshly-inked out of a computer peripheral .

Key characteristics of Op Art?

- Op compositions create a sort of visual tension, in the viewer’s mind, that gives works the

illusion of movement.

- Because of its geometrically-based nature, op art is, almost without exception, non-representational.
- The elements employed (color, line and shape) are carefully chosen to achieve maximum effect
- The critical techniques used in op art are perspective and careful juxtaposition of color （whether chromatic 【identifiable hues】or achromatic【black，white or gray】）
- In op art，positive and negative spaces in a composition are of equal importance.

(Essak, 2019)

2.2.1.17 Pop-Art (1950-1970)

"The term first appeared in Britain during the 1950s and referred to the interest of a number of artists in the images of mass media, advertising, comics and consumer products" (The Bulfinch Guide to Art History,1996, p.109). The most famous of the pop artists, the cult figure Andy Warhol, recreated quasi-photographic paintings of people or everyday objects.

Pop artists thought the abstract expressionist pretentious and over-intense, so the artists brought art back to the material realities of everyday life, to popular culture (hence pop), in which ordinary people derived most of their visual pleasure form television, magazines or comics.

One of the main conceptual objectives of Pop Art was to blur the boundaries between high art and low or popular culture. Pop Art, on the other hand is for the most part emotionally cold towards its subject matter and is associated with mechanical means of reproduction such as photography and printmaking.

The Pop Art movement still influences new generations of artists today. It opened up a world of possibilities by allowing the use of everyday culture and its symbols and objects to become valid subject matter in art, questioning the elitism that was associated with art and bringing it closer to a broader audience (Voytkova, 2016, p. 103).

Conclusion

As the author mentioned in Abstract art development process (2.1.1.6), the actual art movement is developed from Semi-abstract, ranging from art in which we still can see object in impressionist's paintings to non-objective abstract which purely deals with concepts or formulas.

Whether the designers want to express emotional meaning, pursue purely color and form or even nonsense, they can find pretty decent mounts of paintings to extract inspiration. Once we have big picture of the whole development history of abstract art (See Figure 2.6) it is easier to locate the artists' genre and analyze their paintings.

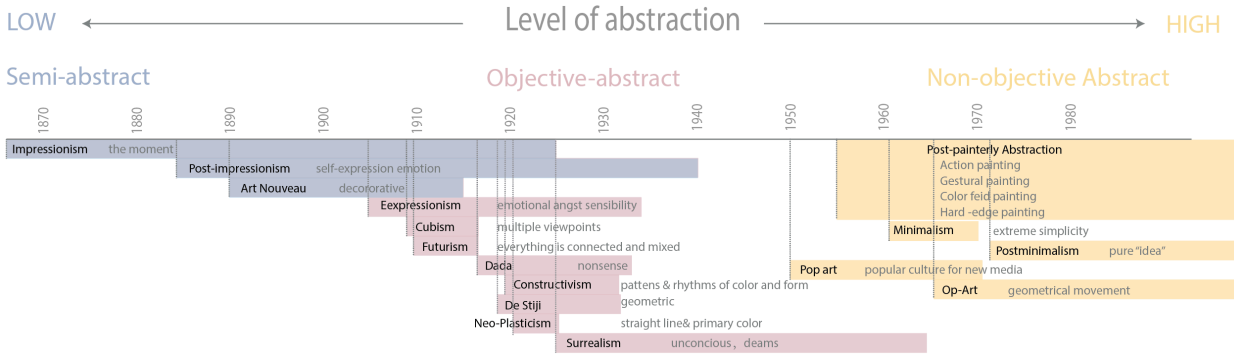


Figure 2. 6

2.2.4 Art and furniture design relationship （Design and art separation and reconciliation）

At first, it is worth it to understand that modern design is based on mass production and the design that benefits the most people (Hu, 2002).

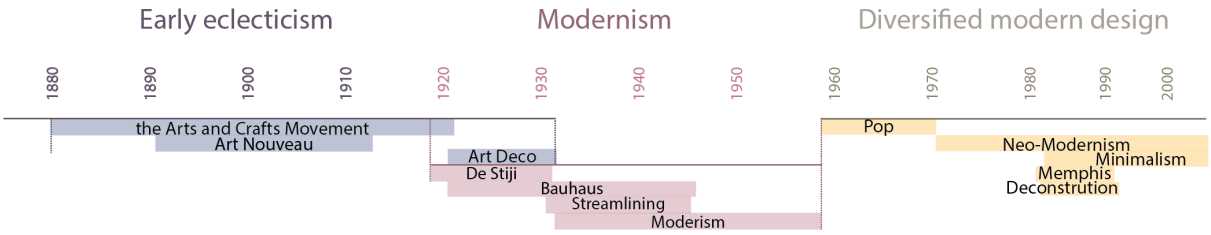


Figure 2. 7

2.2.3.1 The Arts and Crafts Movement (1980-1920)

The arts and crafts movement is a design movement that originated in the late 19th century. The cause of this movement is the decline of the design quality caused by mass production of fields like furniture, interior products and buildings. The purpose of this movement is to produce beautiful and practical products for the public, which embody the democratic ideas of modern design. So, it has been called the beginning of modern design. The main initiator of the arts and crafts movement is William Morris, who advocates that artists should come out of the ivory tower, first proposing the principle of "combination of art and technology". He was against pure art, but he opposed mechanized large-scale production methods and promotes revival craftsmanship. The arts and crafts movement is not a modern design movement in the true sense (Hu, 2002).

The arts and crafts movement emphasize the nature, loyalty to materials and the purpose of use. It creates a fresh style, the decorative pattern is based on natural flowers and plants, the composition is symmetrical and stable, and the design strives to be elegant (Wang, 2002).

2.2.3.2 Art Nouveau (1890-1910)

The essence of the Art Nouveau movement is a decorative movement, which uses abstract natural patterns and curves. Compared with the arts and crafts movement, its lines are more free, smooth, exaggerated, and abstract shapes are often freed from the entity and symbolic.

The movement is influenced by aestheticism and symbolism, pursuing gorgeous and elegant decorative effects (Wang, 2002).

2.2.3.3 Art Deco (1920-1930)

The Art Deco movement is a very special design movement in France, the United States and the United Kingdom in the 1920s and 1930s. It is an extension of the arts and crafts movement and the Art Nouveau movement.

The decorative movement is known for its rich and novel modernity. It likes straight lines and symmetrical abstract forms. The lustrous materials have strong color effects and accept new materials to create a new life in the early 20th century. In terms of style, the Art Deco movement was influenced by the popular Western art genre such as Fauvism, Cubism and Futurism (Zhao, 1992, pp. 138-153).

2.2.3.4 Bauhaus (1919-)

Bauhaus is a design school founded in Germany in 1919. It summarizes the essence of various design reforms since the British arts and crafts movement. It proposes three basic ideas. Firstly, the new unity of art and technology. Secondly, the aim of design is design to people. Last but not least, designs must follow natural and objective rules. These views make modern design gradually move from idealism to realism, that is, to replace artistic self-expression and romanticism with rational and scientific ideas (Wang, 2002).

The Russian Constructivism inherited the theory of the geometric form of Cubism and De Stiji, directly facing the bottom of society, embodying the freedom of democracy and the new force. This idea was quickly accepted by Bauhaus, and several pioneers of constructivism. For example, Kandinsky later laid the foundation for the Bauhaus design basic education, which has far-reaching influence (Liu, 2008).

Key ideas

(1) The application of science and technology. The establishment of modern design is a history of constant conflict and integration between art and technology.

(2) Rational and abstract thinking. In order to achieve the democratic goals of design, the use of machine production is the only way. Affected by this restriction and aesthetics, design creation must conform to the conditions of machine production - standardization and batch production. Therefore, the design must follow certain industrial "standard styles". Abstract geometric forms, precise mathematical quantities, etc. become the abstract and rational core of modernist design thinking.

2.2.3.5 De Stijl (1918 – 1928)

The style school is a loose group organized by some Dutch painters, designers and architects between 1918 and 1928. It uses the monthly magazine De Stijl as a propaganda position to explore new methods and forms such as art, architecture, furniture design and graphic design. The style has a common starting point, the principle of abstraction, that is to say, art should completely eliminate the connection with any natural body, and the combination and composition of z with the basic geometric form to reflect the law of the whole universe - harmony (Liu, 2008).

2.2.3.6 Industry design and Streamline style (1930-1945)

In the United States in the 1920s, when European designers were confused about the relationship between art and technology, ethics and aesthetics, and decoration and function in design, the American architectural community had a very important genre—the Chicago Architecture School. Its leader, Sullivan, first proposed the design tenet of “form following function” and became the most influential creed of modern design movement (Wang,2001).

From the outset, the American design movement was filled with a pragmatic business atmosphere, resulting in a streamlined style in the most commercial-influenced environment.

2.2.3.7 Modernism (1930-1960)

Modernism is one of the most influential styles in the modern design trend. It is almost everywhere in the world. Even today, it can last forever. The reason is that its design theory injects strong democratic ideas and emphasizes, mass production and mass consumption. Modernism advocates the creation of new forms, opposes the use of traditional styles and additional decorations, and advocates mechanical aesthetics, that is, the use of purified geometric forms to reflect the essential characteristics of the industrial age, symbolizing the efficiency and rationality of the machine (Liu, 2008).

2.2.3.8 Modern furniture design (1960-)

After the 1960s, the design of furniture has various design styles. However, from many design genres, we can see that it is obviously influenced by two aspects of design thoughts. On the one hand, it is anti-modernist design ideas, such as Pop design, and Postmodernism, deconstruction, etc.; on the other hand, reinterpretation of modernism, such as neo-modernism, high-tech and other design ideas.

2.2.3.9 Pop and furniture design (1960-)

In the 1960s, young consumers pursued different and novel psychological influences. The design style of the 1960s appeared to form a formalistic trend of pursuing alienation, entertainment, and eccentricity. This trend mainly focused on formal changes. Often function follow the form which may sacrifice the usability, and in the end this trend is only a short-lived one (Hongjun, 2001).

Pop design is one of the main representative styles of this trend. It is more concentrated in the eras like furniture and graphic design. Its design violates the basic principles of mechanized production, ergonomics, economics and practicality of modern design, and eventually becomes a fleeting real pop style (Wang, 2002).

The formalism demonstrated by Pop design has brought unprecedented novelty to the form of furniture design, breaking many traditional furniture concepts. Pop-style furniture design generally prefers high-purity large-area warm colors as the main color, such as lemon yellow, yellow, vermilion, etc., widely used in plastic and man-made composites materials

In the United States, Pop Art Design Thoughts is inextricably linked with the mass consumer culture in the United States in the early days, making the Pop design of the United States strongly symbolic and ridiculous, such as the phone designed by Mickey Mouse, with milk cans. The designer puts together some items that are incompatible with each other to create a discordant and ridiculous pop image that gives a new feeling and visual impact (Hu, 2002).

This style has been widely influential in the furniture design industry. In the design, the pursuit of alienation, eccentricity, entertainment and mystification has greatly satisfied the young people's pursuit of novelty and change in the 1960s (Hu, 2002).

In short, the pop design style is not a simple, consistent style, but a mixture of styles, which has a strong influence on the furniture design of the 1960s, and has invigorated the design atmosphere of the 1960s.

2.2.3.10 Neo-Modernism (1970-)

On the one hand, Neo-Modernism develops modernism to the extreme, so as to break the boring and form new modernism; the other is postmodernism, starting with decoration,

paying attention to the context and tradition, in an attempt to change the simplification and monopoly of modernism (Hongjun, 2001).

The emergence of late modernism was influenced by the popular visual arts at that time. Its design emphasizes structural features, adopts plain finishes, and does not pursue cumbersome decorative effects, reflecting the sense of industry. Pursue geometric composition and machine style. In the product design, it expresses a so-called "hard-edged art", which adopts simple geometric shapes such as cylinders and cubes. It is widely used in industrial materials such as stainless steel and glass. The surface treatment prefers the texture of the material itself (Hongjun, 2001).

In the 1970s and 1980s, neo-modernism maintained the characteristics of modernism and rigorous functionalism and rationalism. It also had its own unique individual expression and symbolic style. Advocating rationalism, functionalism and minimalism.

The new modernist design trend of the specific performance in furniture design is that the surface does not apply any decoration, like the use of chrome-plated steel pipe, the emphasis is on mechanization and geometry (Hongjun, 2001).

On the one hand, neo-modernism insists on scientific rationality, persistence in function and rationality; on the other hand, it has become pluralistic and inclusive, and even tolerant of decoration, but pays attention to the details the texture, color and technical structure of the material to reflect decorative and expressive power.

2.2.3.11 Minimalism (1980-)

Modernism developed into the 1980s and began to flourish in a minimalist style of design. It was the new interpretation of the design master “Less is more” by postmodern

designers. It promotes the simplest structure, the most economical materials, the most refined shape and the purest surface treatment (Hongjun, 2001).

2.2.3.12 Memphis (1980-1990)

The Memphis Group was an Italian design and architecture group founded by Ettore Sottsass in 1980 that designed Postmodern furniture, fabrics, ceramics, glass, and metal objects (Wang,2002).

The character of The Memphis Group

1. Break the horizontal and vertical lines on the composition, using the combination of waveform, surface and line, plane
2. They choose use large number of contrasting and vivid color， especially pink, green and other highly saturated color
3. Use the point, line, surface and other small geometric shapes to make interesting decorative design.

In the Memphis style, because the works are handmade, the number is limited, so it has not been widely popularized and developed. It only lasted for about ten years. But it promotes an attitude that dares to imagine and overthrow, breaks routines and principles, changes historical trends (Wang,2002).

2.2.3.13 Deconstructionist furniture (1980-)

Deconstruction is one of the forms of design exploration in the post-modern design period when modernism faced a crisis and another aspect of postmodernism disgusts some designers or is abused by commercialism. Deconstruction evolved from constructionism, and its essence is the destruction and decomposition of structure.

Deconstruction is the lineage of constructivism in the contemporary era. It rejects synthesis, advocates separation, advocates conflict, breaks, and opposes harmonious unity. In its design, various dissolving and separating methods are often used to reverse the things. In their works, the method of equilibrium symmetry is also dismembered, and the whole is decomposed into countless pieces by overlapping, distorting and fission, which causes multi-level diffusion, and constitutes the deconstructed space of singularity in conflict and opposition (Liu, 2008).

2.2.4 Summary

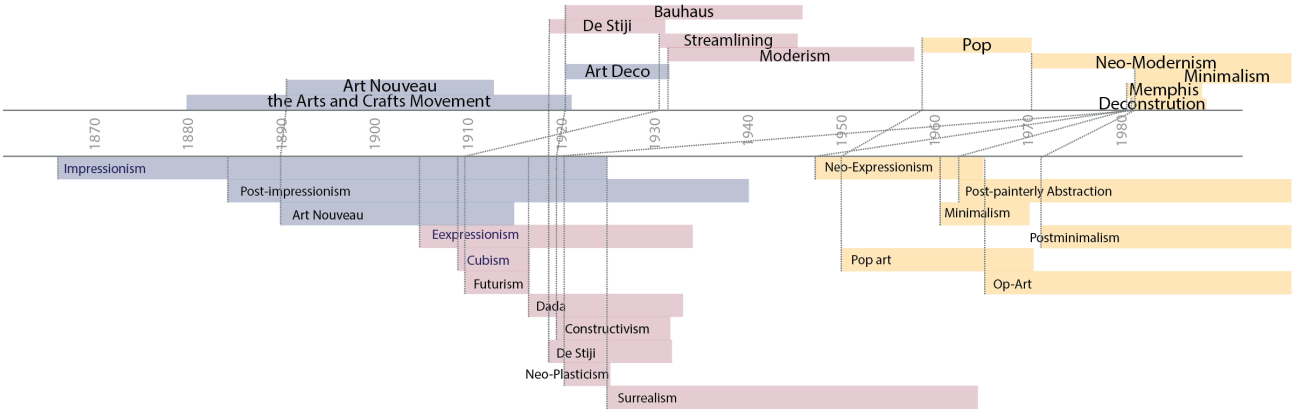


Figure 2. 8

The relationship between abstract art movements and design movements

It is roughly possible to divide the design movement into three stages：Early eclecticism, modernism, and diversified modern design

Early eclecticism

The furniture design in the early stage of modern design, the arts and crafts movement, the Art Nouveau movement, and the Art Deco movement w ere seriously influenced by art, decorations and classical style, emphasizing decoration, but at the same time opposing the plagiarism of tradition and monotonous industrial style. This was the expression of the aesthetic demand for products when the industrial technology was developed but not immature. However,

the manual production model could not adapt to the consumption power and demand of the masses, and did not solve the problem of how to design for mass production.

Modernism

After the First World War, the level of industry and technology has been further developed, and modernism has emerged with functionalism and rationalism as its core. With the development of futurism, expressionism, and constructivism, the style and constructivist works have gradually changed people's aesthetics and influenced modernism. However, the design of this period emphasizes the unity of technology and art, function and form, but the form and decoration and style of furniture design are placed in the most un-important position. The mechanization and automation of production methods have led to the standardization of modernist furniture design to accommodate mass production. At this time, the geometric shape and composition of abstract art are also in line with this production method, so we cannot easily see the combination of artistic style and furniture design at this time, even the modern design that advocates function first.

After World War II, the design of rationalism was also reflected in the combination of design and modern disciplines such as economics, ergonomics, behavioral science, materials science and psychology. Especially in the 1950s, ergonomic principles were widely used in furniture, which made the randomness and sensibility of design become less and less, the form rarely influenced by the personality of the designer, and the design is more scientific. This kind of product that emphasizes scientific and objective design methods to meet people's functional needs is in the public interest and can always be favored by people.

Another reason for the long-lasting design of modernism is that a wide range of new materials reflecting the characteristics of the times are used in the design. New materials and new

processes have greatly enriched the design language, from plastic furniture, fiberglass furniture, and wood-based panel furniture, to the use of glass, stainless steel, aluminum alloy and other modern materials combined furniture.

Diversified modern design

After the 1960s, Western countries have gradually entered abundance of society. The economic structure has also shifted from the primary and secondary industries of material production to the tertiary industry, which is characterized by non-material production. From low-tech industries to high-tech industries, products have shifted from standardization and stereotypes to diversity and individualization. From the "quantity revolution" in the early post-war period to the "quality revolution," the adjustment of economic structure has made the industry appear small and scattered. The tendency has been to change and promote the Western concept of consumption. The diversified demand also led to a variety of furniture styles after the 1960s, but it can be clearly divided into two major genres, on the one hand, anti-modernist design ideas, such as pop design, postmortem design, deconstruct design, etc., focusing on form; on the other hand, it is a reinterpretation of modernism, such as neo-modernism design, minimalist design and so on.

Design is the product of the times, not independent. Designers are always looking for a balance between form and function. Beauty has always been part of human needs. We can see from Figure 2.8 art movements were always before the design movements which means the way we appreciate products is influenced by the art.

2.3 Ways to analysis abstract art

Who	When	Where	What	How	Why
Contexts Artists	Date Historical	Provenance Location	Visual elements Line Shape Light and value Color Texture Pattern Space Structure / layout format Time and motion	skills techniques methods processes	overall mood Subject matter themes issues narratives stories ideas instinctual response symbolic value

Table 2. 3

5W1H way to analysis art

When we start to analyze abstract art generally, we can use 5W1H as a tool to analysis abstract art (5W1H are questions whose answers are considered basic in information gathering or problem solving (Hart, 1996)).

We can get a wider information by asking who did the works, where they did them, and when they did them to support our analysis and get a better understanding of the artist' purpose. The most important part is to analyze the art itself to support our furniture design. What and how will be our focus points when we analyze abstract art**.**

2.3.1 General Information(contexts)

All art is in part about the world in which it emerged (Barrett, 1999).

We can identify when, where and why the work was created and its original intention or purpose.

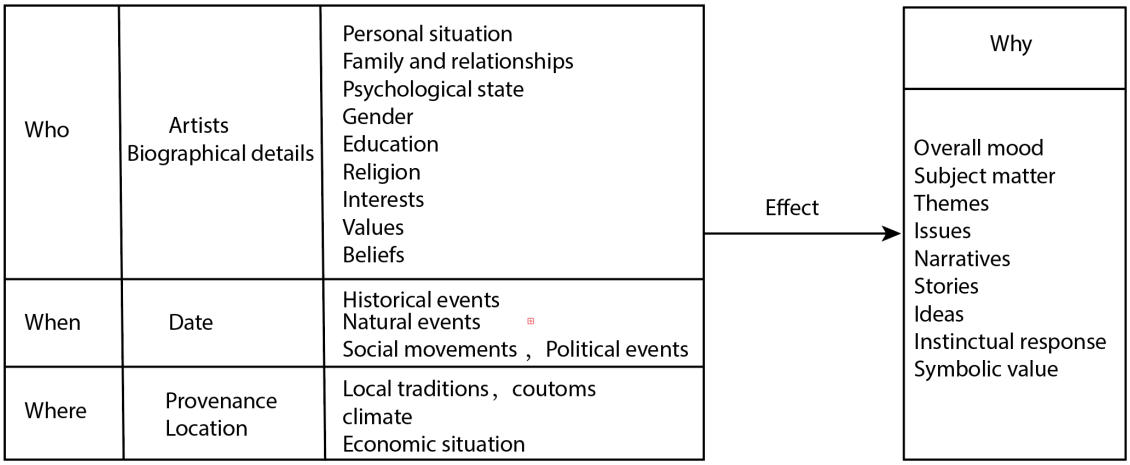


Table 2. 4

Supportive information to analyze art

- **Geographic information**：This information can give you influential messages like natural events 、local traditions 、climate、and economic situations.
- **Time information**: Events like political events 、social movements such as feminism, historic events, political events, and cultural events may in some way influence the artists.
- **Key biographical details**: Artists' personal backgrounds may be relevant to understanding the art. We may get into artists' biographical details like personal situation; gender; education; family and relationships; psychological state; religion; interests, values and beliefs (Gale, 2018).
- **Original Intention:** private sale; commissioned for a specific owner; private viewing; public viewing commemorative; educational; promotional; illustrative; decorative; confrontational; useful or practical utility; communication; created in response to a design brief (Gale, 2018).

2.3.2 Visual elements

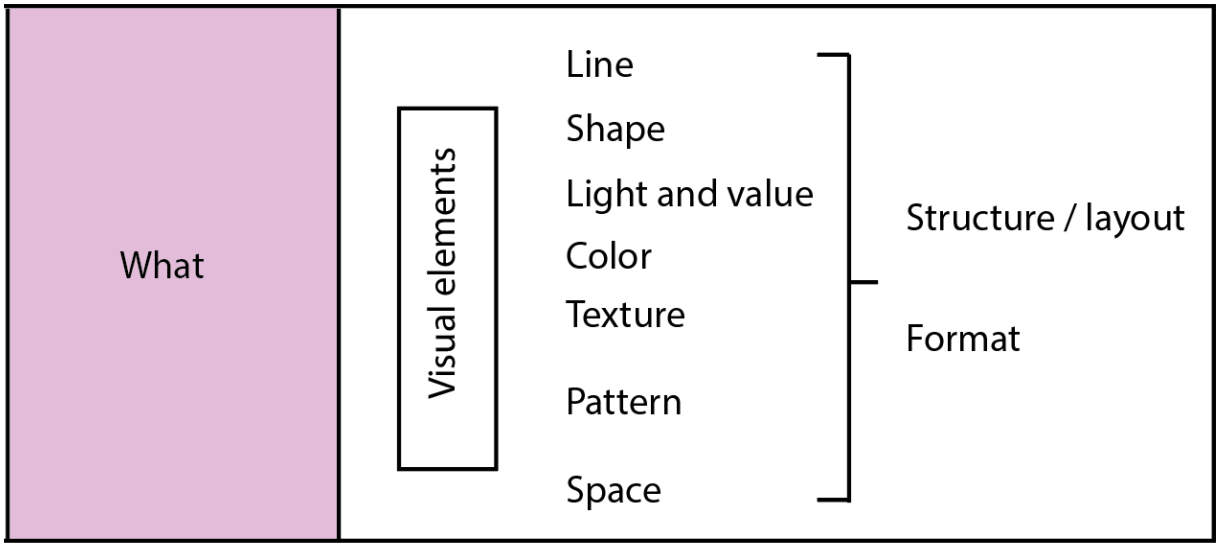


Table 2. 5

Visual elements of art

There can be different, competing, and contradictory interpretations of the same artwork. An artwork is not necessarily about what the artist wanted it to be about (Barrett, 1999), which means it not necessary to understand from the original artist's points of view. General information is helpful while as designers we can have our own understanding and we can directly start with visual elements to analyze abstract art.

2.3.2.1 Dot

The point may be defined as the smallest elementary form, but this definition is not exact. It is difficult to fix the exact limits of the concept "smallest form." The point can grow and cover the entire ground plane unnoticed (Kandinsky, 1947).

Size: How much space it occupies the painting

Shape: The second inevitable fact concerns the outer limit of the point which determines its external form

Figure 2. 9

Examples of point forms (Kandinsky, 1947)

The point is a small world cut off more or less equally form all sides and almost torn out of its surroundings.

The point digs itself into the plane and asserts itself for all time. Thus, it presents the briefest, constant, innermost assertion: short, fixed and quickly created.

The point, which is

1.a complex (size and form)

2.a sharply-defined unit (Kandinsky,1947)

2.3.2.2 Line

2.3.2.2.1 Quality of line:

Depth: Thick- thin

Weight: Light -heavy

Direction: Tendency

Angles: Vertical -horizontal 、 degree

Length: Short- Long

We can define a line scientifically by determining its depth, weight, direction, angle and length.

2.3.2.2.2 Type of line：

We can use words like:

Soft; Bold; Delicate; Feathery; Indistinct; Faint; Intermittent; Irregular; Freehand; Expressive; Ruled; Mechanical; Loose; Blurred; Dashing; Meandering; Gestural; Fluid; Flowing; aged; Spiky; Sharp and so forth (Gale, 2018)to describe the line. And designers should analyze the line to understand what ideas, moods, emotions, and atmosphere the artists want to evoke.

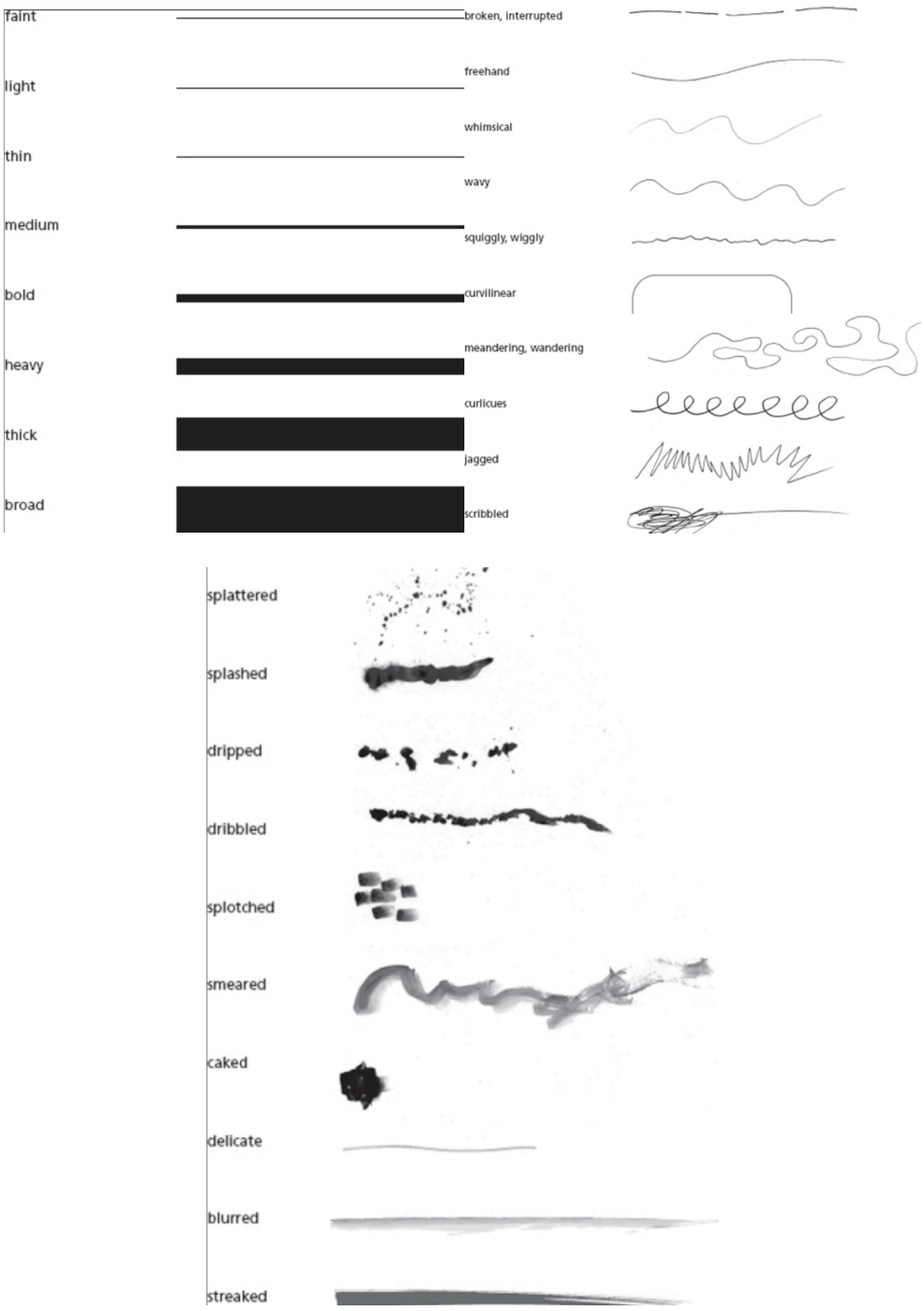


Figure 2. 10

Examples of different lines (Day, 2013, pp. 21,22,23)

2.3.2.2.3 Dominating lines

In a painting there may be a lot of lines. When we analyze them, we can start with boundary lines, outlines, and construction lines and then analyze the dominating lines based on direction and relative relations.

- Boundary lines: could divide, segment, or separate different areas;
- Outlines: used to define form and edges.
- Construction lines or contour lines: describe form
- Parallel lines: could create a sense of depth or movement through space within a landscape;
- Horizontal lines: could create a sense of stability and permanence;
- Vertical lines: could suggest height, reaching upwards or falling;
- Abstract lines: could create contrast or emphasis, balance the composition;
- Angular / diagonal lines: may suggest tension or unease;
- Intersecting perpendicular lines：could suggest rigidity, strength;
- Chaotic lines: may suggest a sense of agitation or panic;
- Curving / organic lines: may suggest nature, peace, movement or energy.
- Leading lines: could manipulate the viewer's gaze, directing vision or lead the eye to focal points;
- Repeating lines: could simulate material qualities, textures, patterns or rhythm (Gale, 2018)

2.3.2.2.4 Kandinsky theory of line

The geometric line is an invisible thing. It is the track made by the moving point; that is, its product .it is created by movement (Kandinsky,1947, p.57).

All line forms can be reduced to two cases:

1.Application of one force: Straight line

2.Application of two force:

a) single or repeated, alternate action of both forces: Angular line

b) simultaneous action of both forces: Curved lines (Kandinsky,1947, p.57).

2.3.2.2.4.1 Straight line

A. Straight line: a force coming from without moves the point in any direction

This is the straight line whose tension represents the most concise form of the potentiality for endless movement.

Typical kinds:

- Horizontal line

Coldness and flatness are the basic sounds of this line, and it can be designated as the concise form of the potentiality for endless cold movement.

- Vertical line

The vertical line is the most concise form of the potentiality for endless warm movement.

- Diagonal line

The diagonal line is the most concise form of the potentiality for endless cold-warm movement (Kandinsky,1947, p.58).

These three types are the purest forms of straight lines

Free straight lines （unbalanced line）

Centric

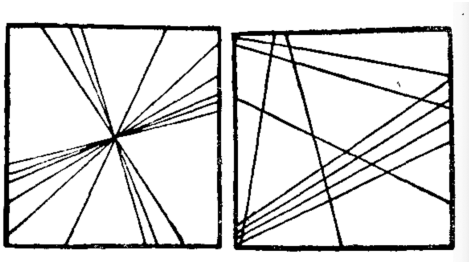


Figure2. 11

Free straight lines, centric; acentric (Kandinsky,1947, p.72).

Graphic form	Pictorial Form
Straight line	Primary colors
Horizontal	Black
Vertical	White
Diagonal	Red(or grey ,or green)
Free straight line	Yellow and blue

Figure2. 12

B. Angular Lines

The simplest forms of angular lines consist of two parts, and the result of two forces which have discontinued their action after a single thrust.

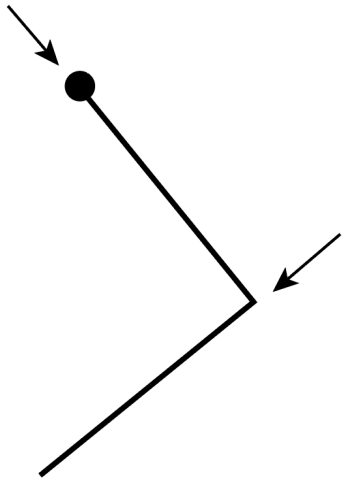


Figure2. 13

(Kandinsky,1947, p.69)

The differences between the countless angular lines depend entirely upon the sizes of the angles, in accordance with which they can be divided into three typical groups:

a. with acute angles — 45°

b. with right angles — 90°

c. with obtuse angles —135°

The sounds of this first three forms thereby correspond:

1. the cold and controlled
2. the sharp and highly active
3. the clumsy, weak and passive. (Kandinsky,1947, p.72)

Graphic form	Pictorial Form	The sounds
Acute angles — 45°		Cold and controlled
Right angles — 90°		Sharp and highly active
Obtuse angles —135°		Clumsy, weak and passive

Table2. 6

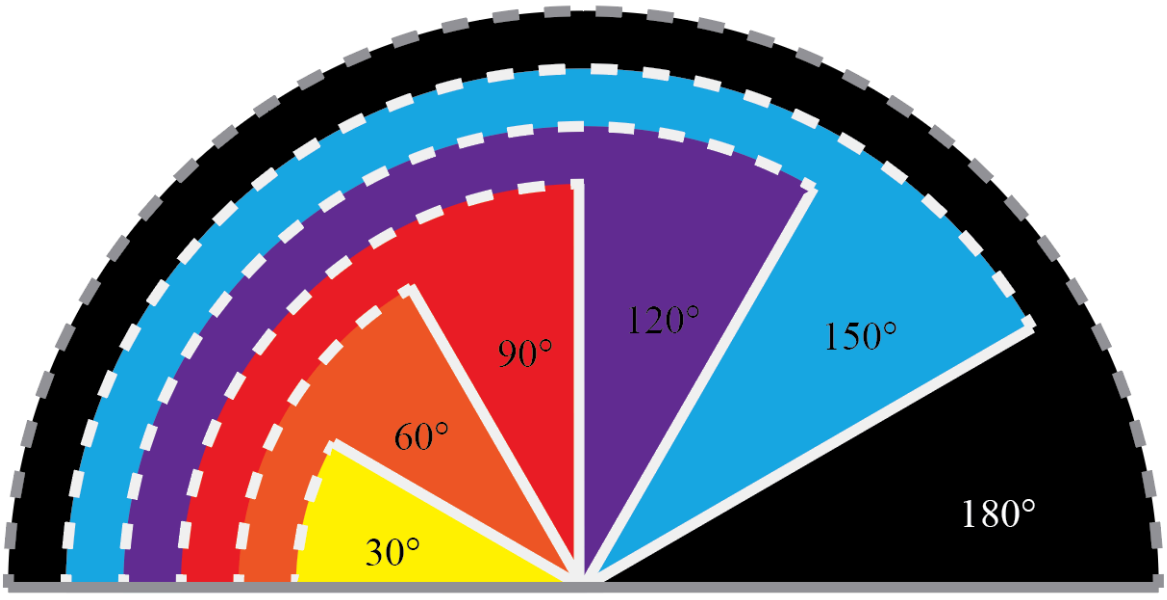


Figure2. 14

System of typical angles ⇄colors (Kandinsky,1947, p.73)

Particularly the passiveness in the obtuse angle, the almost missing forward tension, gives this angle a light blue tone. Since, the typical angles in their continued development can form planes, the further relationships between line-plane-color arise automatically.

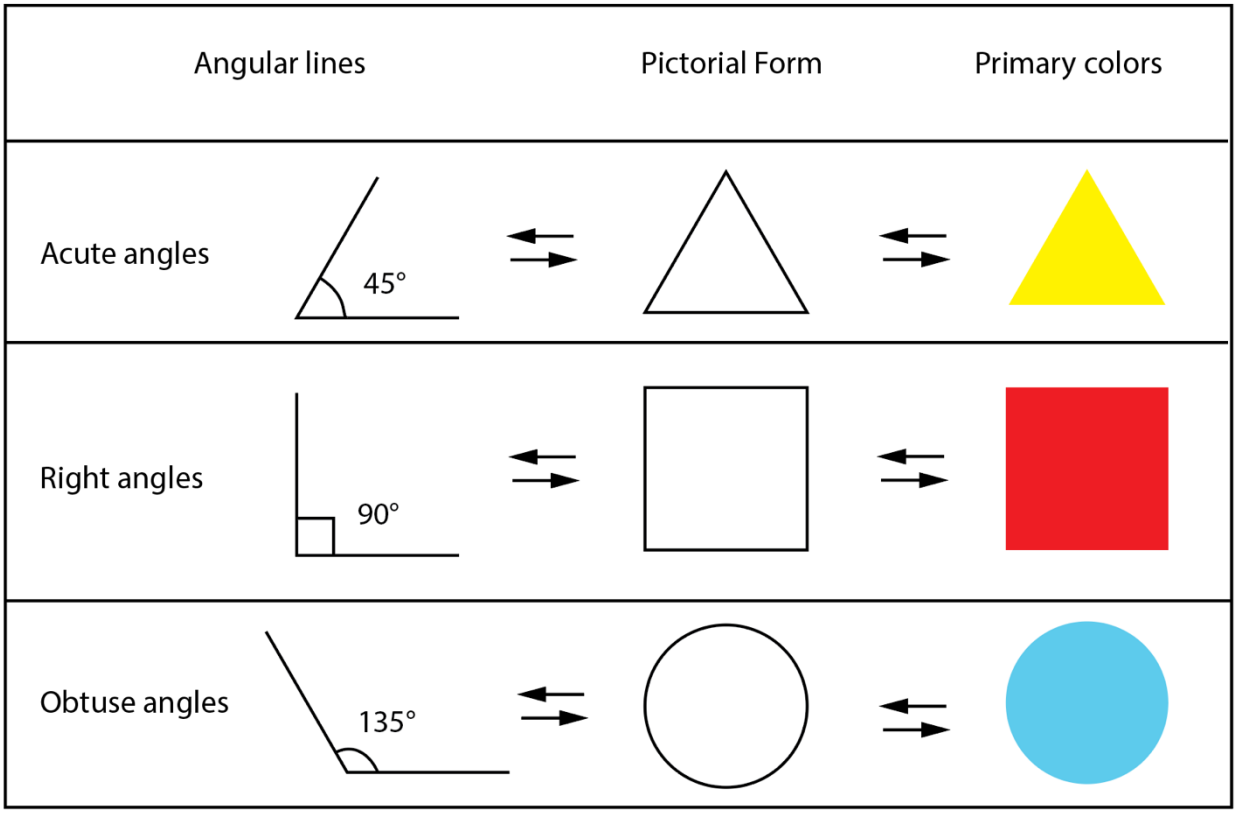


Table2. 7

2.3.2.2.4.2 Curved line

A. The simple curved line.

When two forces act upon the point in such a way that one force continually, but always to the same degree, exceeds the other in pressure, a curved line is created.

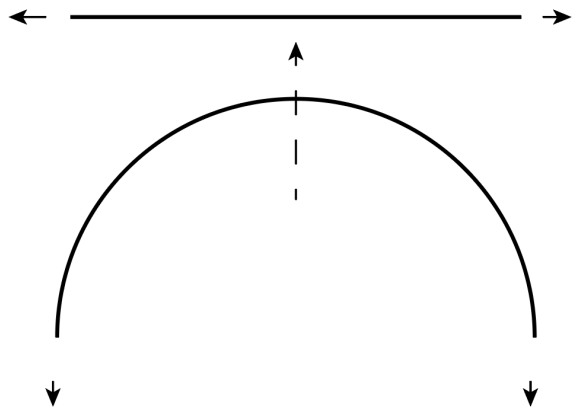


Figure2. 15

Tensions of straight and curved lines (Kandinsky,1947, p.80)

B. Complex curved or waved-like

1. geometric parts of a circle
2. free parts
3. various combinations of these

curve -geometric wave -like:

equal radius – uniform alternation of positive and negative pressure. Horizontal course with alternating tensions and release.

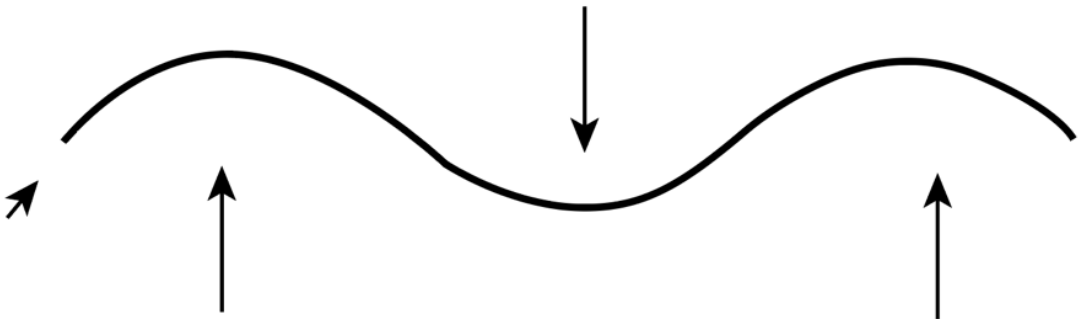


Figure2. 16

Fig. Equal radius (Kandinsky,1947, p.85).

C. Curve—free wave -like

1. the geometric character disappears
2. positive and negative pressure with irregular alternation, whereby the former gets much the upper hand of the latter.

Figure2. 17

The line itself, spontaneous accentuation s of lines

Figure2. 18

The line itself

D. Complex of lines (composition)

The simplest case is the exact repetition of a straight line at equal intervals–the primitive rhythm (Fig. 2.20) or in uniformly increasing intervals (Fig. 2.21) or in unequal intervals spontaneous accentuation (Fig.2.22)

Figure2. 19

Figure2. 20

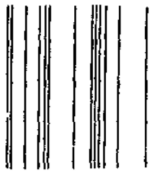


Figure2. 21

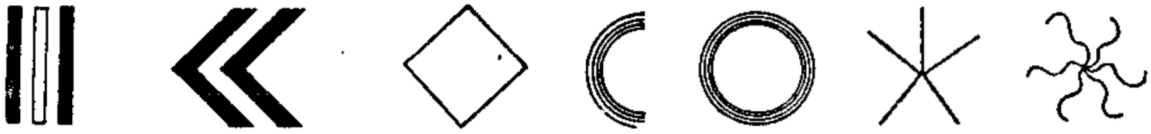


Figure2. 22 Figure2. 23 Figure2. 24 Figure2. 25 Figure2. 26 Figure2. 27 Figure2. 28

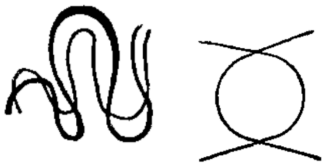


Figure2. 29 Figure2. 30

Fig2.23 repetition of a straight line with alternation of weights

Fig2.24 repetition of an angular line

Fig2.25 opposed repetition of an angular line, plane formation

Fig2.26 repetition of a curved line

Fig2.27opposed repetition of a curved line, repeated plane formation

Fig2.28central-rhythmic repetition of a straight line

Fig2.29central-rhythmic repetition of a curved line

Fig2.30 repetition of an accented curved line by means of an accompanying line

Fig2.31 contrasting repetition of a curved line

(Kandinsky,1947, p.95)

2.3.2.3 Shape and form

A shape is any discernibly bounded area defined by line, value, color or texture, or by some combination of these elements (Goldstein, 1989, p. 62).

2.3.2.3.1 Visual language

We need to identify a dominant visual language within the shown forms and shapes. Possible word to describe it could be complex; minimal; geometric; angular; rectilinear; curvilinear; organic; natural; fragmented; distorted; free-flowing; varied; irregular (Gale, 2018). We can divide shapes into three kinds: schematic; sensual in nature; interpenetration of the two shapes.

Geometric shapes:

Geometric shapes are those purer configurations we associate with the forms of geometry such as a circle, triangle or square. When geometric shapes predominate, in whatever style of art, they almost always are of a sharply focused, fast-moving, and reasoned kind.

Organic shapes:

Organic shapes recall the irregular, often undulating contours in nature. They show little or no passages of straight or evenly curved edges. When organic shapes predominate in a work, the imagery is often of a tactile, less focused, even sensual kind (Goldstein, 1989, p. 64).

Direction:

The directional cues that shape provides play a key role in generating moving actions necessary to a work's compositional resolution (Goldstein, 1989, p. 74).

2.3.2.3.2 Ways to processes the edges

Blur or fade away or at the edges, as if melting into the page; Ripped or torn; Distinct and hard-edged (Gale, 2018).

2.3.2.3.3 Variety and repetition of shapes

Repetition may reinforce ideas, balance composition and/or create harmony / visual unity; variety may create visual interest or overwhelm the viewer with chaos (Gale, 2018).

2.3.2.3.4 Organize of shape

We need consider how shapes are organized in relation to each other, or with the frame of the artwork (i.e. grouped; overlapping; repeated; echoed; fused edges; touching at tangents; contrasts in scale or size; distracting or awkward junctions.

2.3.2.4 Value

> All objects are revealed by light that enables us to see their structure and their value, that is, their degree of lightness or darkness between the tonal extremes of white and black. The particular degree of an object's value results from a combination of two factors: its inherent local tone, the value of object itself, excluding any effects of light, and the values created by an illuminating source (Goldstein, 1989, p. 88).

2.3.2.4.1 Tonal range

A wide tonal range been used in the artwork: a broad range of darks, highlights and mid-tones.

A limited tonal range: pale and faint; subdued; dull; brooding and dark overall; strong highlights and shadows, with little mid-tone values.

2.3.2.4.2 Light souses

What is the position of the light sources within the artwork or scene? Is there a single consistent light source or multiple sources of light？ The light sources include: sunshine; light bulbs; torches; lamps; luminous surfaces.

The effect of these choices may be: mimics natural lighting conditions at a certain time of day or night; figures lit from the side to clarify form; contrasting background or spot-lighting used to accentuate a focal area; soft and diffused lighting used to mute contrasts and minimize harsh shadows; dappled lighting to signal sunshine broken by surrounding leaves;

chiaroscuro used to exaggerate theatrical drama and impact; areas cloaked in darkness to minimize visual complexity; to enhance our understanding of narrative, mood or meaning (Gale, 2018).

2.3.2.4.3 Shadows

Are shadows depicted within the artwork?The effect of shadows may be: anchors objects to the page; creates the illusion of depth and space; creates dramatic contrasts, etc.

2.3.2.5 Color

2.3.2.5.1 Basement of color

Primary Colors

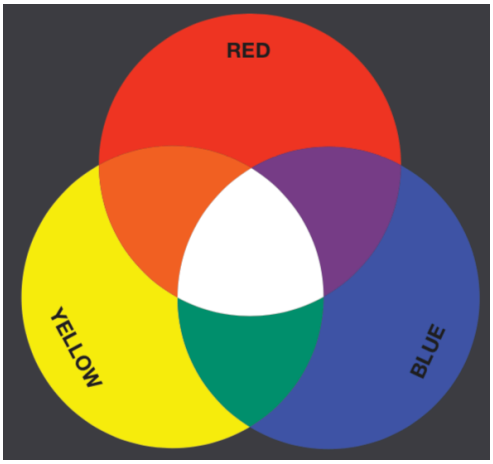


Figure2. 31

Primary Colors

The three colors in the central equilateral triangle, red, blue, and yellow, are the primary colors. They are called “primary” because they cannot be made by mixing any other colors (Day, 2013, p. 52).

Color schemes of the artwork: harmonious; complementary; primary; monochrome; earthy; warm; cool/cold. Has the artist used a broad or limited color palette (i.e. variety or unity)? Which colors dominate?

The intensity of the colors: vibrant; bright; vivid; glowing; pure; saturated; strong; dull; muted; pale; subdued; bleached; diluted (Gale, 2018).

Color contrast: extreme contrasts; juxtaposition of complementary colors; garish / clashing / jarring.

Kandinsky theory of color

Color is the most powerful medium in the hand of painter. It has a psychic as well as a physical effect upon the observer. It can influence his tactile, olfactory and especially aural senses, as well as his visual sense, and in chromotherapy it has been shown that "red light stimulates and excites the hearts, while blue light can cause temporary paralysis."

Color is the artist 's resource to influence the human soul.

Color symbolism

Two great divisions of color occur to the mind at the outset：into warm and cold， and into light and dark.

Blue: heavy color, it repeats from spectator, moving toward its ow center

It beckons to the infinite, arousing a longing for purity and the super-sensuous

Light blue =sound of flute dark blue =the sound of cello

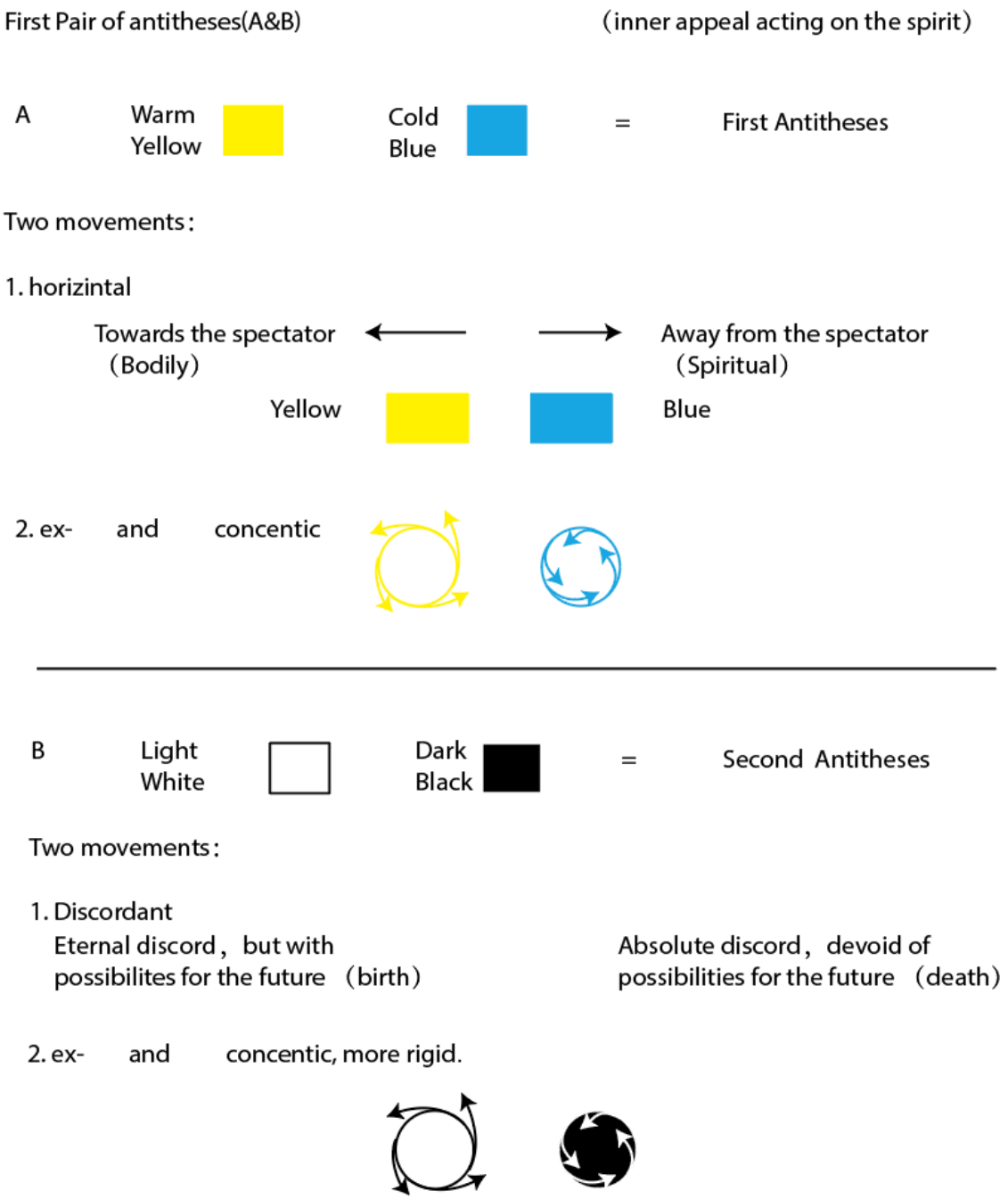
Yellow: Disturbing influence, an insistent aggressive character.

the color of earth, no profound meaning, spread out from its own center and advance to the spectator from the canvas

Shrill(sound of a canary or of a brass horn， and is the sour taste of lemon)

White: it is the symbol of a world void of all material quality and substance. It is the color of beginning. Sound of earth during the white period of the ice age.

Black: eternal silence. It is without hope. It signifies termination and therefore the color of mourning



A well-balanced mixture of blue and yellow produces green.

Green: the concentricity of blue nullifies the eccentricity of yellow

It is passive and static, and can be compared to the so-called bourgeoisie self-satisfied, fat and healthy. Placid, long drawn middle tones of the violin

Red: a determined and powerful intensity. It glows in itself; gives a feeling of strength, vigor, determination, triumph. In music, it is a sound of trumpets, strong, harsh, and ringing.

Grey: A blend of black and white produces gray, which is silent and motionless.

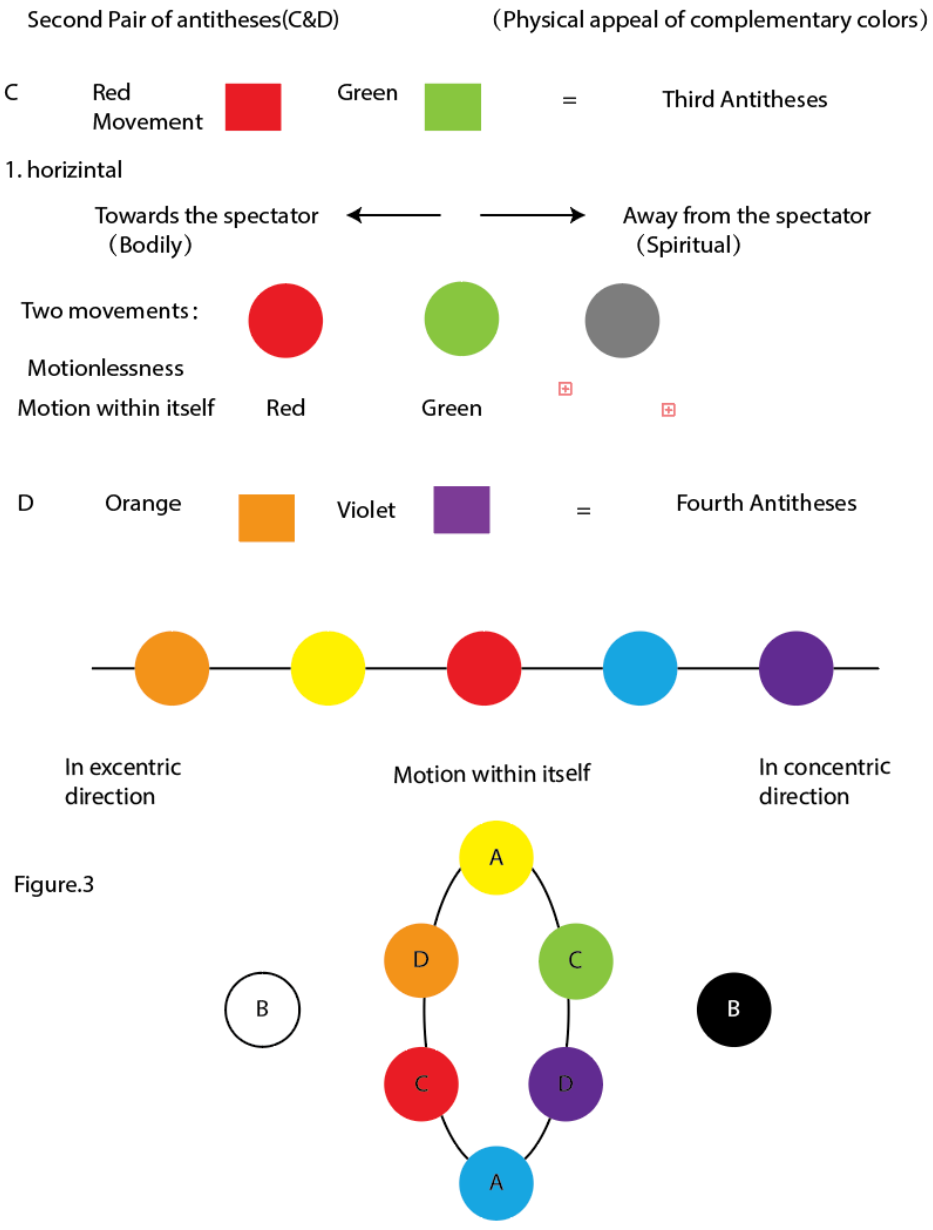


Figure.3

The antitheses as a circle between two poles, i.e.,the life of color between birth and death。

2.3.2.5.2 Effect of color

The effect of color choices could be: expressing symbolic or thematic ideas; descriptive or realistic depiction of local color; emphasizing focal areas; creating the illusion of aerial perspective; relationships with colors in surrounding environment; creating balance; creating rhythm/pattern/repetition; unity and variety within the artwork; lack of color places emphasis upon shape, detail and form； creating atmosphere (Gale, 2018).

2.3.2.6 Texture/ Pattern

For artists, the term texture has two meanings: there are the tactile textures, the textures of the things we draw and paint， such as wood， water， silk or skin， and there are the media textures， the textures of the various materials used in drawing and painting. The first kind of texture is an illusion -we imitate certain surface qualities of an object's substance; the second kind of texture is a fact – the ink line is thin, fluent, and sharply defined; the chalk line is broad, grainy, and less sharply defined. Both kinds of texture stimulate our sense of touch. Sometimes, too, the term texture is used to define a discernible pattern or density of lines ， shapes， or masses in particular area of a work； what we might call area texture (Goldstein, 1989, p. 152).

So, when we analyze art are there any interesting textural, tactile or surface qualities within the artwork like bumpy; grooved; indented; scratched; stressed; rough; smooth; shiny; varnished; glassy; glossy; polished; matte; sandy; grainy; gritted; leathery; spiky; silky?

How are these created? The possible way will be inherent qualities of materials; impasto mediums; sculptural materials; illusions or implied texture, such as cross-hatching; finely detailed and intricate areas; organic patterns such as foliage or small stones; repeating patterns; ornamentation, etc.

Next question will be how textural or patterned elements affects the artwork. The function could be used intermittently to provide variety; repeating pattern creates rhythm; patterns broken create focal points; textured areas create visual links and unity between separate areas of the artwork; balance between detailed/textured areas and simpler areas; glossy surface creates a sense of luxury; imitation of texture conveys information about a subject, i.e. softness of fur or strands of hair (Gale, 2018).

2.3.2.7 Space

Normally, we are unware of space and only aware of what it contains. Space is mostly as the "medium" the field or area in which line, space, and volume phenomena take place (Goldstein, 1989, p. 127).

2.3.2.7.1 Spatial depth

In paintings normally, the surface is flat while some artists still want to express the depth of space. The method could be changing the shape and scale to have a sense of spatial depth wether to keep it shallow or deep. More specifically the artist would get the spatial impression by layering of foreground, middle-ground, background; overlapping of objects; use of shadows to anchor objects; positioning of items in relationship to the horizon line; linear perspective – learn more about one point perspective here; tonal modeling; relationships with adjacent objects and those in close proximity – including the human form – to create a sense of scale; spatial distortions or optical illusions; manipulating scale of objects to create 'surrealist' spaces where true scale is unknown; gradians in size, value, clarity; diagonal directions. (Gale, 2018)

2.3.2.7.2 Viewpoint

Unusual viewpoint: worm's view; aerial view; looking out a window or through a doorway; a scene reflected in a mirror or shiny surface; looking through leaves; multiple viewpoints combined; linear perspective; isometric perspective.

The effect of this viewpoint: allows certain parts of the scene to be dominant and overpowering or squashed; condensed and foreshortened; or suggests a narrative between two separate spaces; provides more information about a space than would normally be seen (Gale, 2018).

2.3.2.7.3 Density

Is the emphasis upon mass or void? How densely arranged are components within the artwork or picture plane?

2.3.2.8 Composition

The study of composition may be described as an examination of the structural and organizational aspects of that language; of how certain visual phenomena make our images solidify into coherent expressions that can be universally understood. The term composition refers to the total visual nature of a particular work's dynamic and depictive occurrences and to their resolution into a balanced and unified whole.

2.3.2.8.1 Structure/ layout

Formal system of arrangement or mathematical proportion: rule of thirds; golden ratio or spiral; grid format; geometric; dominant triangle; or circular composition; central location; two centers; the bridge; cantilever suspended in the air; the even spread; the radial burst; emphasis on diagonality; emphasis on horizontality; emphasis on verticality.

Arrangement less predictable: chaotic, random, accidental, fragmented, meandering, scattered; irregular or spontaneous

A clear intention with alignment and positioning of parts within the artwork: edges aligned; items spaced equally; simple or complex arrangement; overlapping, clustered or concentrated objects; dispersed, separate items; repetition of forms; items extending beyond the frame; frames within frames; bordered perimeter or patterned edging; broken borders.

The effect of these visual devices has: imply hierarchy; help the viewer understand relationships between parts of artwork; create rhythm.

2.3.2.8.2 Fifteen general modes of presentation

1. Deep space 2. Shallow space 3. Density (busy picture- filling) 4. Sparsity (simplicity) 5. Dense and sparse (a complex and an "empty") 6. Two-dimensionality 7. Volume and space dominant 8. Straight edge dominant 9. Straight versus curve 10. Linear, closed shapes 11. painterly, open shapes 12. Line dominant 13. Value dominant 14. Texture dominant 15. Color dominant (Goldstein, 1989, pp. 237-245)

2.3.2.8.3 Principle of composition

- Unity and Variety
- Balance (symmetry, asymmetry)
- Emphasis and Subordination
- Scale and Proportion (weight, how objects or figures relate to each other and the setting)
- Mass/Volume (three-dimensional art)
- Rhythm
- Simplicity
- Hierarchy

(Goldstein, 1989, pp. 1-22)

2.4 Furniture design

The focus of furniture study are the components construction joints and materials, in order to achieve the goal of mass customization and iterate with art elements.

2.4.1 Furniture definition

> Furniture is objects of applied arts intended for mobile and permanent furnishing of residential interiors. Among other things, it serves for storage, work, eating, sitting, lying down, sleeping and relaxing. Furniture can be used individually, in suites or sets (Smardzewski, 2015, p. 47).

2.4.2 Furniture Category

In terms of functionality, furniture can be divided into the following groups:

- for sitting and lounging,
- for reclining,
- for working and eating meals,
- for learning,
- for storage,
- multifunctional furniture and
- complementary furniture.

Due to the method of binding certain structural components, subassemblages and assemblages, furniture can be divided into:

- non-disassembling, produced in the form of compact blocks, which makes their disassembly impossible,

- disassembling, produced in the form of solids that provide the possibility of repeatable disassembly and reassembly and
- for individual assembly, sold in packages containing elements for repeatable assembly and disassembly.

Taking into account the characteristics arising from the design of the furniture, three main groups can be distinguished: **case, skeletal and upholstered furniture.**

2.4.3 Case furniture

Definition

Case furniture is the goods of a volume structure, in which the surface elements limit and close a given space.

Elements of case furniture

- The main element: without which the furniture piece loses its functional nature and the construction becomes a mechanism,
- A supplemental element: without which the construction can be maintained, but the furniture piece does not perform the intended functions and
- Compensation element: without which the function and the construction can be preserved; however, its use significantly improves the stiffness, strength, durability and reliability.

Case furniture elements	
Definition	Case furniture is the goods of a volume structure, in which the surface elements limit and close a given space.
Main element	Forming the function and construction of the furniture piece
Supplemental element	Improve furniture performance
Compensatory element	Improves the stiffness, strength, durability and reliability.

Table2.4. 1

Division of case furniture according to function

Case furniture can be single- or multifunctional, which enables use of them in different ways, for example:

- a wardrobe, a tall case furniture piece designed primarily to store clothing, bedlinen, office binders, folders, drawings, etc.,
- library bookcase, a cupboard with shelves and mostly glass doors designed to store books,
- bookcase, a furniture piece consisting of a few or a dozen or so shelves hung on the side walls, with or without a rear wall, open or partially closed,
- glass case, glass cupboard or top part of a dresser, for storing decorative ceramics, dishes and jewelry
- dresser, serves to store dishes, table linen, cutlery, etc.,
- buffet, a type of dresser, intended to be laid with occasional meals,
- chest of drawers, a low cupboard with drawers for storing bedlinen and clothing,
- overhead cupboard, cupboard at the ceiling used for storing rarely used items,
- wall unit, a set of furniture that fulfils all storage functions and at the same time serves to divide rooms
- built-in set, wall set of furniture, usually closed, used for storage.

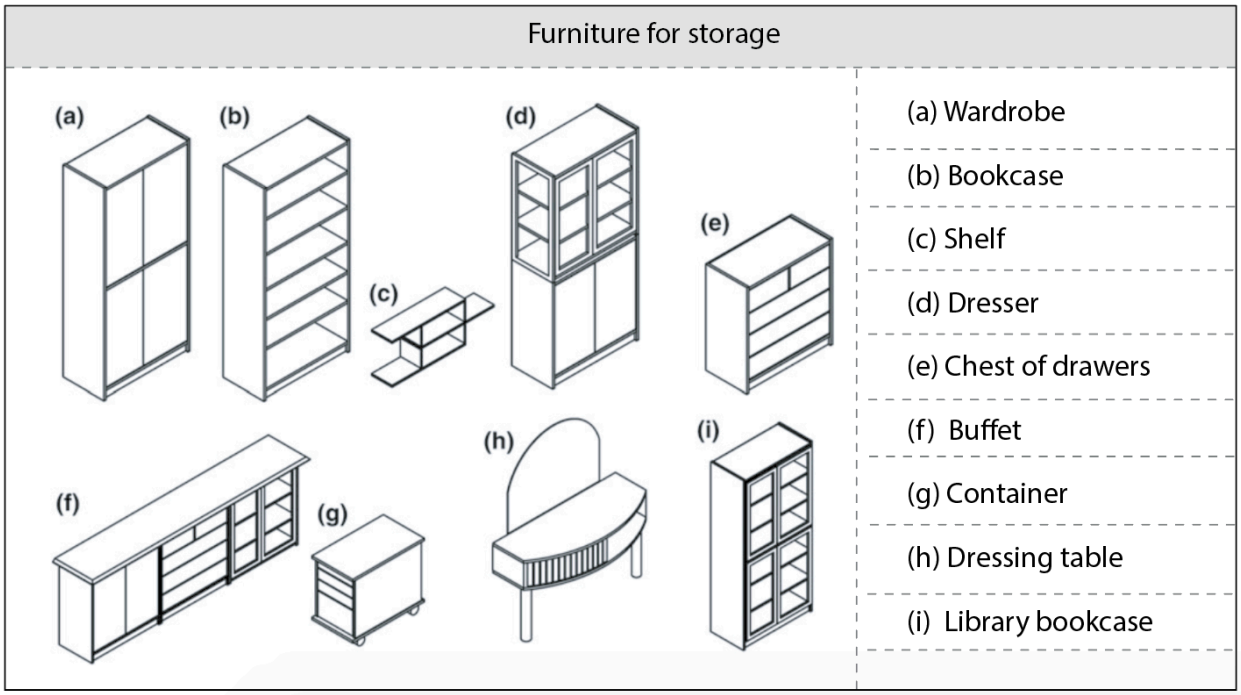


Figure2.4. 1

Characteristic of Case Furniture

Sub assemblages and assemblages include:

Subassemblages and assemblages	
Side	Constituting a side limitation,
Socle	Consisting of a bottom and at least 3 interconnected socleskirts
Body	Consisting mostly of structurally bonded side walls, bottom, top and rear wall
Base	A bearing function
Frame	Consisting of connected rails
Chest	Assemblage fulfilling the function of a container
Base frame	A skeletal structure
Cabinet	Fulfilling the function of a container, e.g. desk cabinet and davenport cabinet
Drawer	A movable container, open at the top
Blinds	Closing a case furniture piece by drawing, flexible(bendy) in the direction of motion

Table2.4. 2

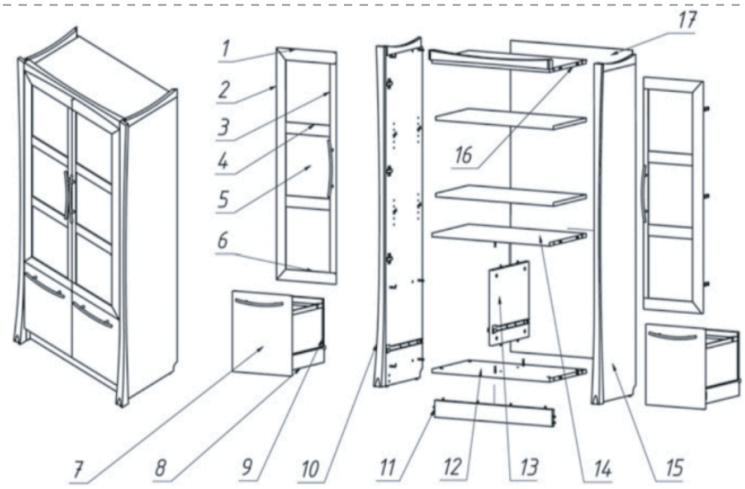
In case furniture, the following elements are distinguished

Case furniture elements	
Wall	an element forming a fixed outer limitation acting as a container depending on the position, there are side, front, rear walls, etc.,
Side wall	The fixed side exterior limitation
Partition wall	A fixed vertical separation of the entire space
Front wall	Front wall, a fixed front outer limitation
Rear wall	Rear wall, a fixed rear outer limitation
Bottom	Front wall of the drawer,
Top	Bottom
Slide	(top flange for flange structures), the fixed outer top ,limitation of the body A movable element which provides an additional worktop when pulled out.
Worktop	Top plane
Vertical partition	An element which constitutes a fixed vertical division of parts of space
Horizontal partition	Fixed horizontal division of space
Shelf	Loosely arranged horizontal board element for placing various objects,
Panel	Between the rails of the frame
Bar	Bar
Door	A movable element with a vertical axis of rotation
Sliding doors	Amovable element shifted horizontally
Flap door	Doors with a horizontal axis of rotation,
Leg	The bearing element , front or rear leg
Complementing element	
Strip	Strip, acting as a slider, sup- porter, resistant, connector, etc
Runner	The strip element, top, lateral and bottom runners
Gantry	Bottom gantry and top gantry, constitutes a slider of drawers
Thickener	Reinforcing and decorative character
Rail	The element of the frame, longitudinal, transverse, central rails, etc.,
Post	Constitutes vertical reinforcement or filling in the base or the body of the unit
Handle	Handle

Table 2.4. 3

Case furniture elements example (Table2.4.4 Table2.4.5 Table2.4.6)

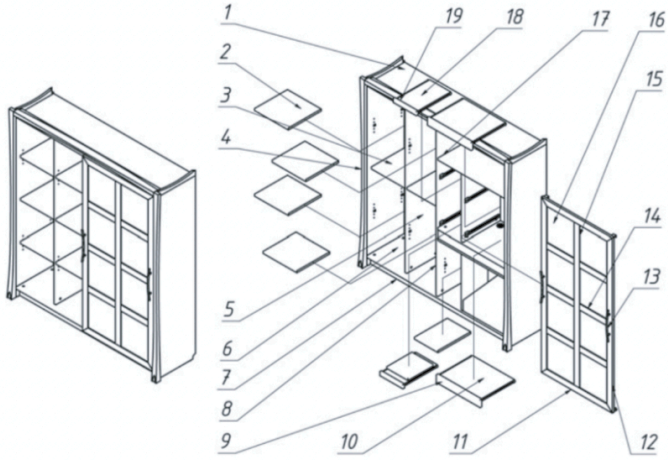
Names of elements of case furniture—library



1	top transverse rail	2	left longitudinal rail	3	right longitudinal rail	4	central transverse rail	5	panel
6	bottom transverse rail	7	front of the drawer	8	side wall of the drawer	9	rear side of the drawer	10	laminated board
11	socle skirt	12	bottom	13	vertical partition	14	horizontal partition	15	side wall
16	top	17	rear wall						

Table 2.4. 4

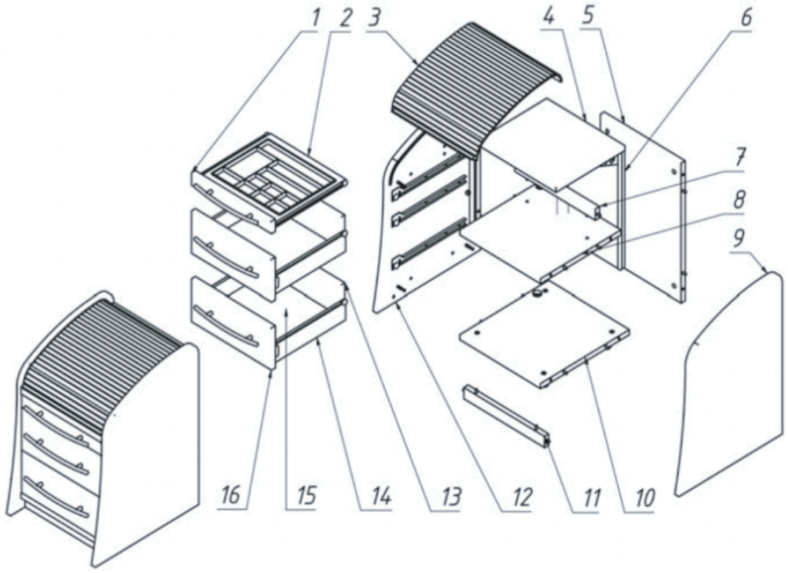
Names of elements of case furniture—wardrobe



1	top	2	shelf	3	horizontal partition	4	laminated board	5	vertical partition
6	bottom	7	laminated bottom board	8	vertical partition	9	front of the slide	10	slide
11	bottom transverse rail	12	right longitudinal rail	13	handle	14	central transverse rail	15	central longitudinal rail
16	panel	17	horizontal partition	18	slide	19	front of the slide		

Table 2.4. 5

Names of elements of case furniture—container



1	front of the case	2	case	3	blinds	4	top	5	rear wall
6	partition wall	7	skirt	8	horizontal partition	9	right side wall	10	bottom
11	socle skirt	12	left side wall	13	rear wall of the drawer	14	side wall of the drawer	15	bottom of the drawer
16	front of the drawer								

Table 2.4. 6

Case furniture is built mainly from panel elements. Typically, these elements are located relative to each other in such a way that closes space from five or six sides. Due to the nature of the structure, visible parts or external elements, case furniture is divided into (Table. 2.4.3):

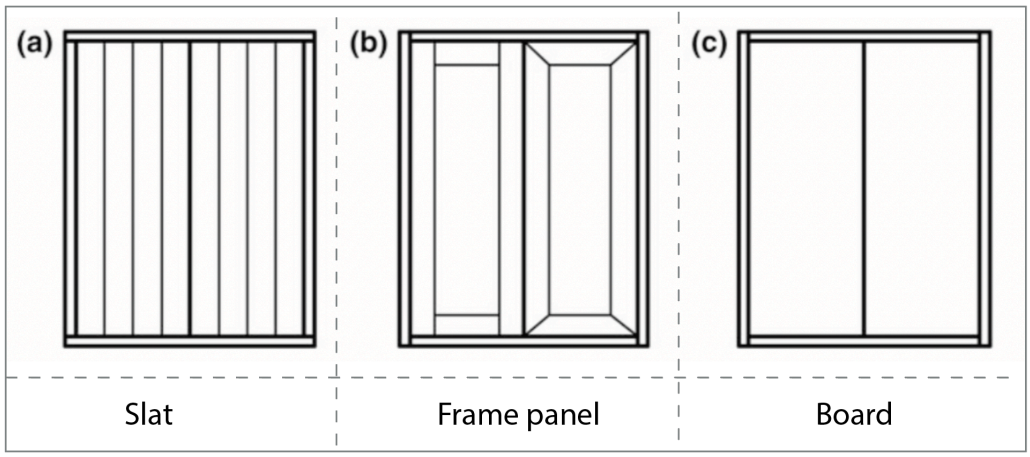


Figure 2.4. 2

(Smardzewski, 2015, p. 58)

Given the solutions of designing support construction of case furniture, bases are distinguished in the form of a socle, a frame and legs (Figure2.4. 3)

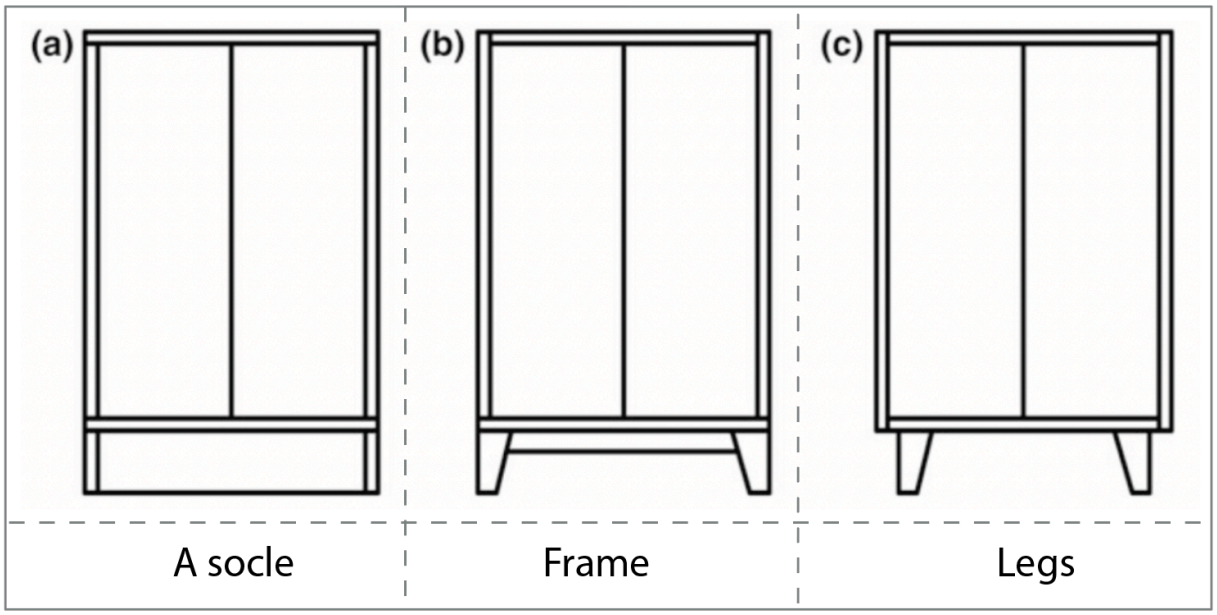


Figure 2.4. 4

Body of furniture placed on sole, frame, legs(Smardzewski, 2015, p. 58)

2.4.4 Skeletal furniture

Definition

Skeletal furniture is the product of linear and surface structure, in which elements do not close a space.

Elements of Skeletal furniture

Skeletal Furniture		
Definition	Skeletal furniture is the products of linear and surface structure, in which elements do not close a space.	
Main element	Definition	Forming the function and construction of the furniture piece
	Typical case	Leg, backrest board, seat frame, top panel
Complementary element	Definition	Providing only the function of furniture piece
	Typical case	Insert of worktop, armrest
Compensatory element	Definition	Improve satisfactory stiffness, strength, durability and reliability of construction
	Typical case	Support, bar

Table 2.4. 7

- Main element, forming the function and construction of the furniture piece (leg, backrest board, seat frame, top panel—usually the worktop of the table),
- Complementary element, providing only the function of furniture piece (insert of worktop, armrest) and
- Compensatory element, which can improve satisfactory stiffness, strength, durability and reliability of construction (support, bar).

Division of Skeletal furniture

Skeletal furniture is made of elongated elements with small cross sections, in the shape of a square, rectangle, triangle, circle, oval, etc., not closing space within it, e.g. chairs, armchairs,

tables and flower beds. The shape of the cross sections of these elements determines the next division of frame furniture into:

- beam furniture, in which the cross section of elements is a polygon and
- rod furniture, which is built using elements of circular, ellipse, oval or similar to circular cross sections.

Depending on how the seat or worktop is supported, we can distinguish furniture of the following designs (Table2.4. 8): board, cross, with rails, without rails, frame, column, rack and one piece.

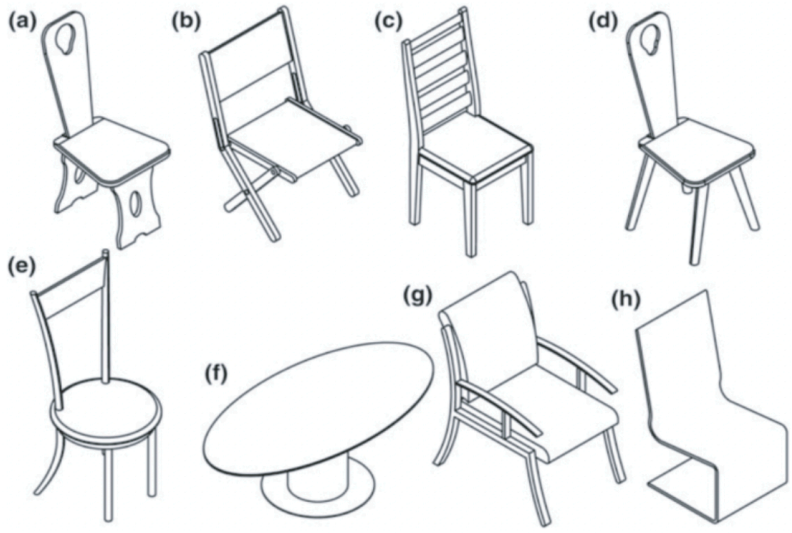
Division of furniture depending on seat or worktop support	
	(a) Board (b) Cross (c) With rails (d) Without rails (e) Frame (f) Column (g) Rack (h) One piece

Table 2.4. 9

Characteristic of Skeletal Furniture

The following elements are distinguished in skeletal furniture, chairs and tables:

Names of elements of Subassemblages and assemblages of skeletal furniture	
Side	Constituting the side limitation,chair sides and armchair sides
Backrest	Backrest
Rail module	Rail module
Base	A bearing function for the furniture piece
Armrest module	In skeletal furniture usually built from an armrest and support
Frame	Consisting of connected rails, fulfilling the bearing function
Seat frame	Seat frame, a bent element with a closed circumference or U-shaped which constitutes the main structural connection of the seat
Seat	Seat, an upholstered assemblage or subassemblage for sitting
Skeleton	composed of structurally bound,beam elements, rod elements, pipe elements, etc.constitutes the bearing structure

Table2.4. 10

Example：

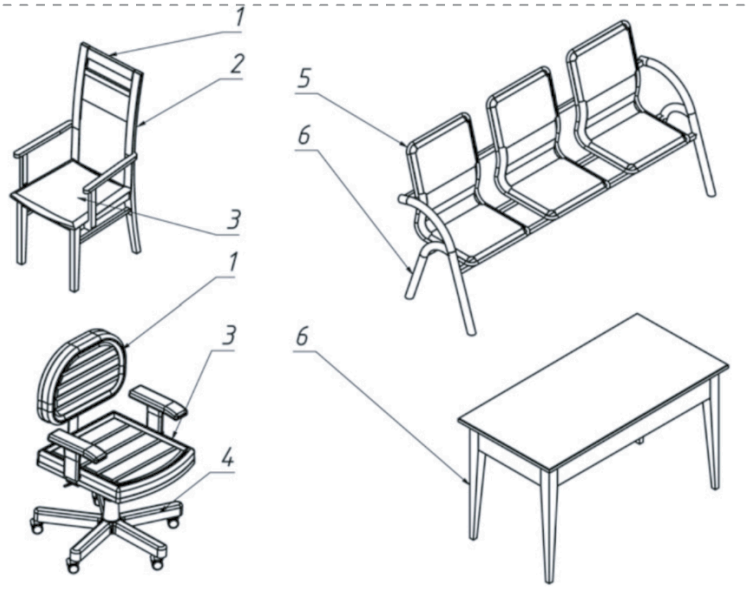
Names of subassemblages of skeletal furniture									
									
1	backrest	2	side frame	3	seat	4	frame	5	seat backrest subassemblage
6	frame								

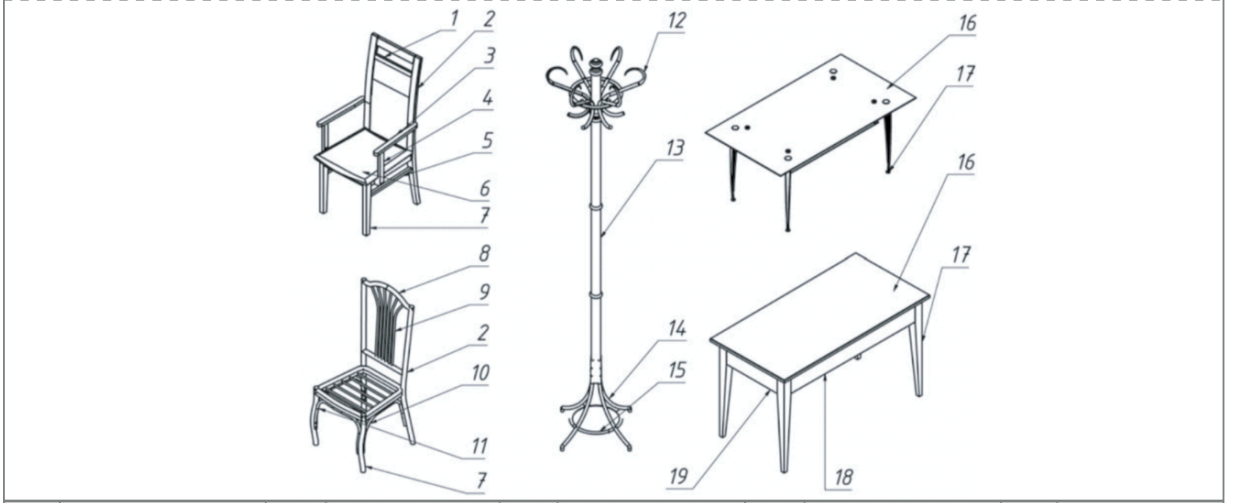
Table 2.4. 11

Names of elements Skeletal Furniture	
Backrest board	Backrest board
Seat board	Seat board
Worktop	Usable, top plane
Armrest	Support of arms
Armrest support	Armrest support
Leg	Bearing element, the back or front leg,
Support leg	An element fulfilling the function of a back leg and support of the backrest An bent element in the shape of an inverted U, and these are two support legs connected from the top in bent furniture
Rail	Constituting the primary horizontal structure, frontal, side, rear, longitudinal or transverse
Bar	Constituting additional strengthening of structural connections, longitudinal, transverse, etc.
Column	A vertical bearing element, e.g. of a free-standing hanger
Block	Strengthening of the main structural nodes and fulfils functions, e.g. of slider and resistance
Connector	A type of curve-shaped bar in bent furniture,
Rim	A bent with a closed circumference, additional strengthening of construction connections
Semi-rim	A bent with an open circumference, in the shape of the letter U, strengthening of connections
Arch	A bent in one or a few planes of an open circumference, strengthening of connections
Muntin	An element for filling a particular space in an openwork manner
Insert	A movable element for increasing the dimension of the worktop An element that fills the space between the rails and other external limitations of the backrest, side, etc., Backrest insets, side insets, etc., and in special cases
Hanger head	A rolled or sharp-edged element, constituting the co-axial extension of the hanger post,
Hanger hook	Usually formed in the shape of the letter J or S,

Table 2.4. 12

Example：

Elements of skeletal furniture



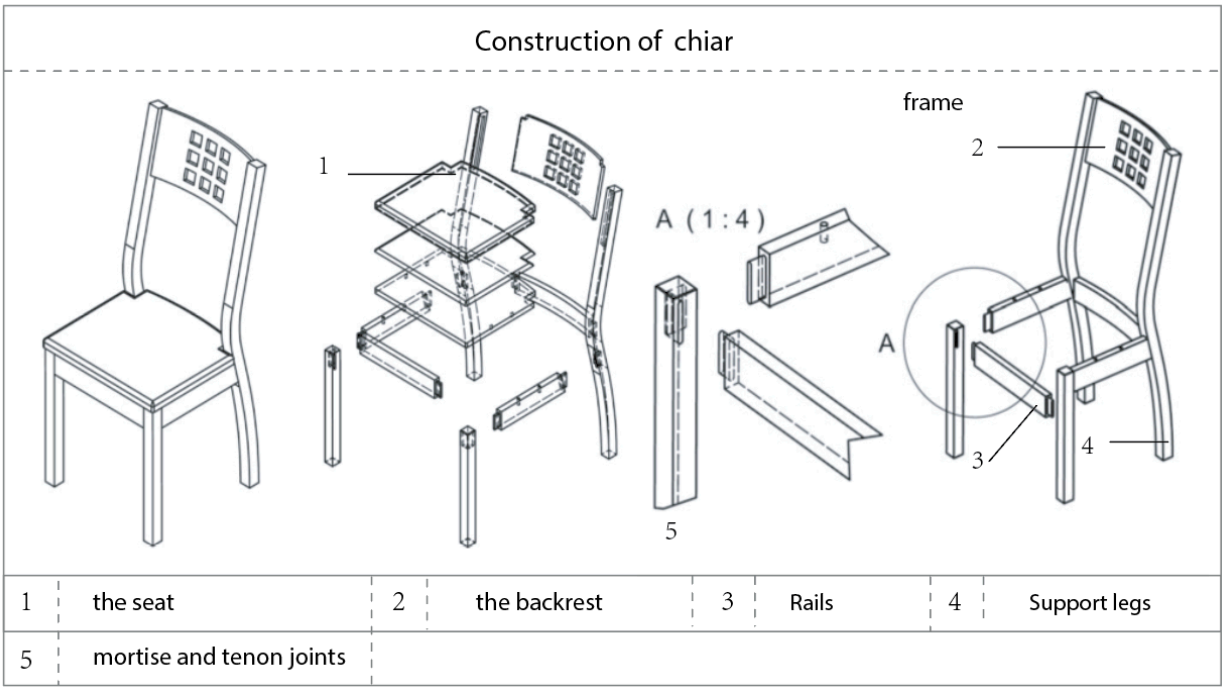
1	backrest board	2	support leg	3	armrest	4	armrest support	5	bar
6	seat board	7	front leg	8	arch	9	filling	10	arch
11	arch	12	hanger hook	13	column	14	leg	15	rim
16	worktop	17	leg	18	longitudinal rail	19	transverse rail		

Table 2.4. 13

(Smardzewski, 2015, pp. 85-87)

2.4.4.1 Chairs

The construction of a carpentry chair is shown in Table2.4. 14. This construction uses only single covered L-type mortise and tenon joints.

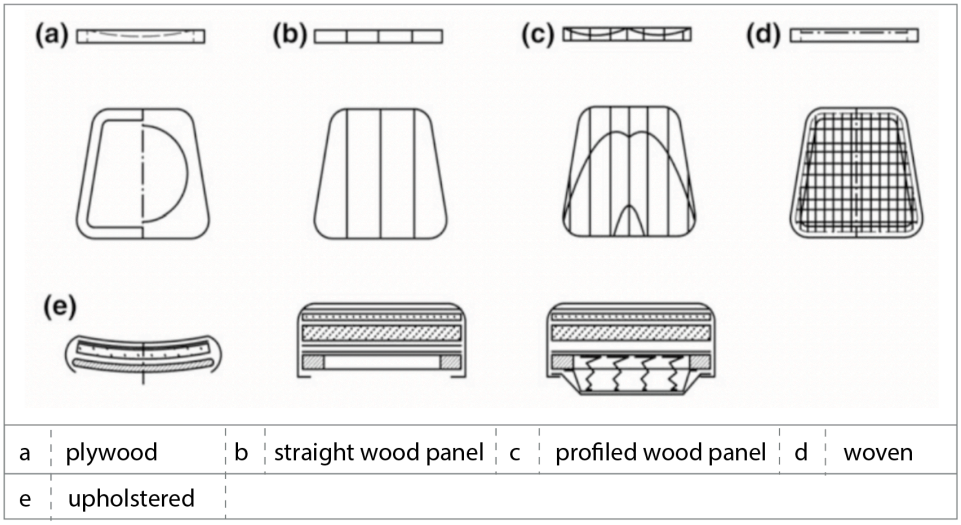


1	the seat	2	the backrest	3	Rails	4	Support legs
5	mortise and tenon joints						

Table 2.4. 15

Construction of a carpentry chair with mortise and tenon joints

Examples of constructions of seats:



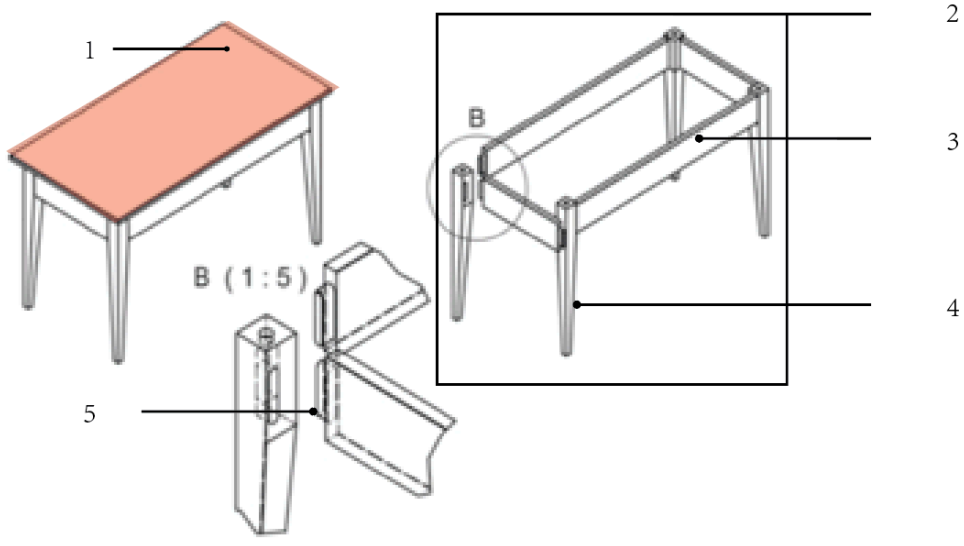
a	plywood	b	straight wood panel	c	profiled wood panel	d	woven
e	upholstered						

Table 2.4. 16

2.4.4.2 Tables

The main components of tables are the top panel and frame, which consists of rails

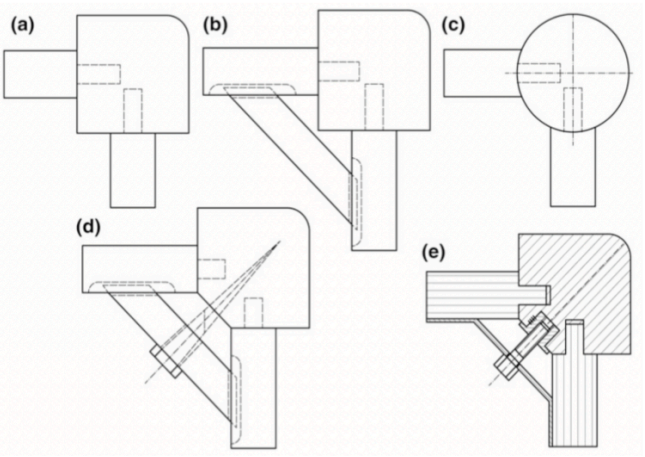
and legs. A typical connection of the legs of a table with the rails is a single covered L-type mortise and tenon join (Smardzewski, 2015, p. 272)



1	The worktop	2	Frame	3	Rails	4	Table legs
5	Mortise and tenon joints						

Table 2.4. 17

Rails and legs of a table can also be connected using screws and special connectors. Examples of inseparable and separable connection of rails with the legs using the connections are shown in Table2.4.18.



a	straight single mortise and tenon joints,
b	straight single mortise and tenon joints with a connector,
c	straight single mortise and tenon joints used for a rod element,
d	straight single mortise and tenon joints with a screw connector
	and e straight single mortise and tenon joints with a bolt connector

Table 2.4. 18

Examples of mounting working tops of tables using: (Smardzewski, 2015, p. 273)

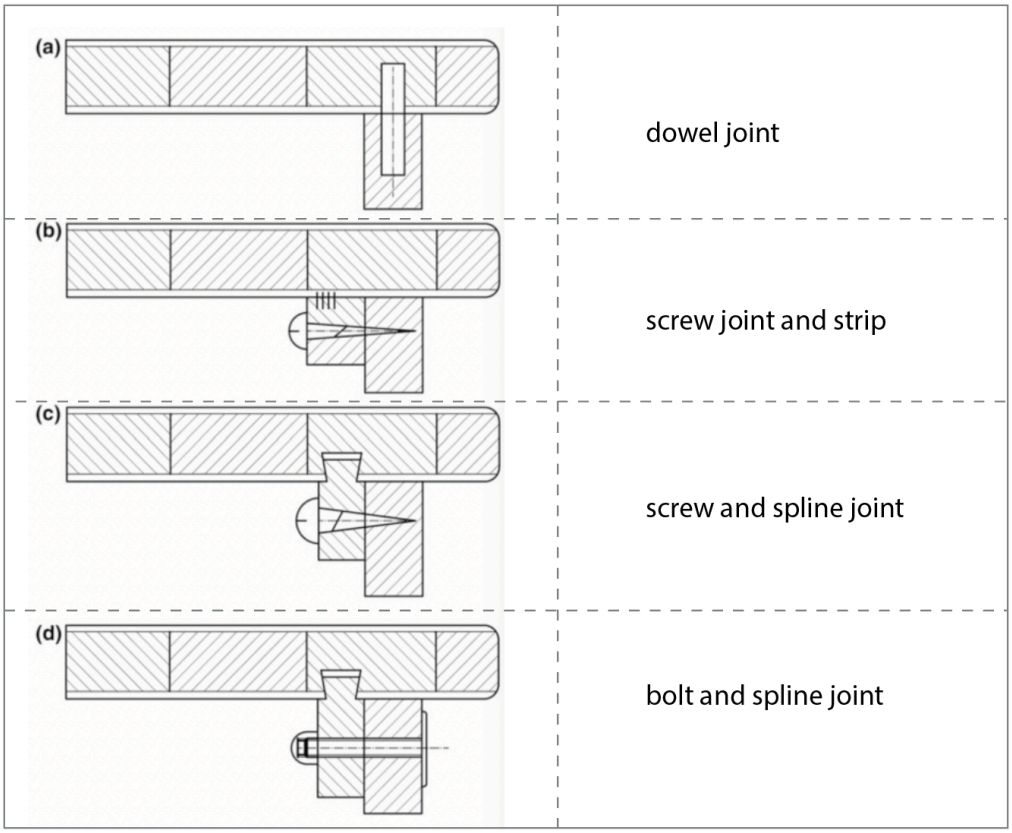


Table 2.4. 19

Bearing structures of high tables occur mainly in rail forms (Fig.2.4.6), with the legs of the following cross sections: polygonal, rectangular, triangular, circular, oval and irregular.

Examples of the shapes of rails

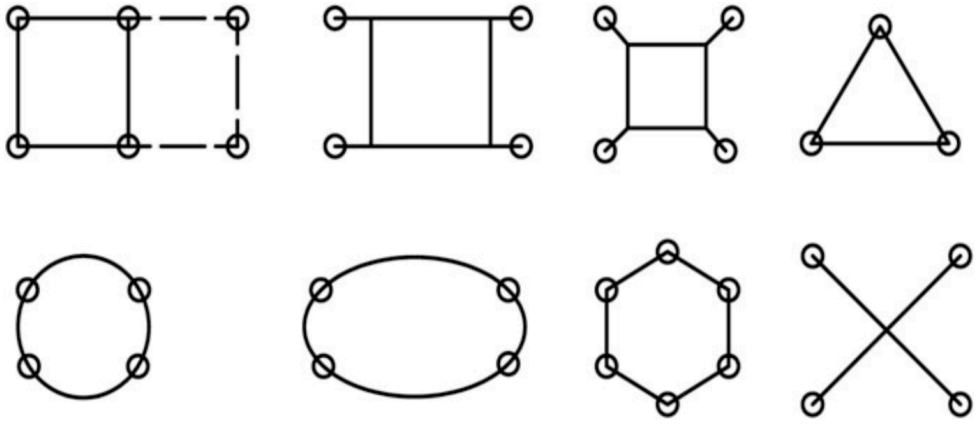


Figure 2.4. 5 (Smardzewski, 2015, p. 78)

Depending on the purpose and functions of the designed table, the top boards can have a regular form of squares, rectangles, ellipses, ovals and circles, or in the form of irregular surfaces limited by a polygon, splain or polyline. In employee table for offices, designers search for shapes of top surfaces which allow their connection into new usable forms (Figure2.4. 6) (Smardzewski, 2015, p. 87).

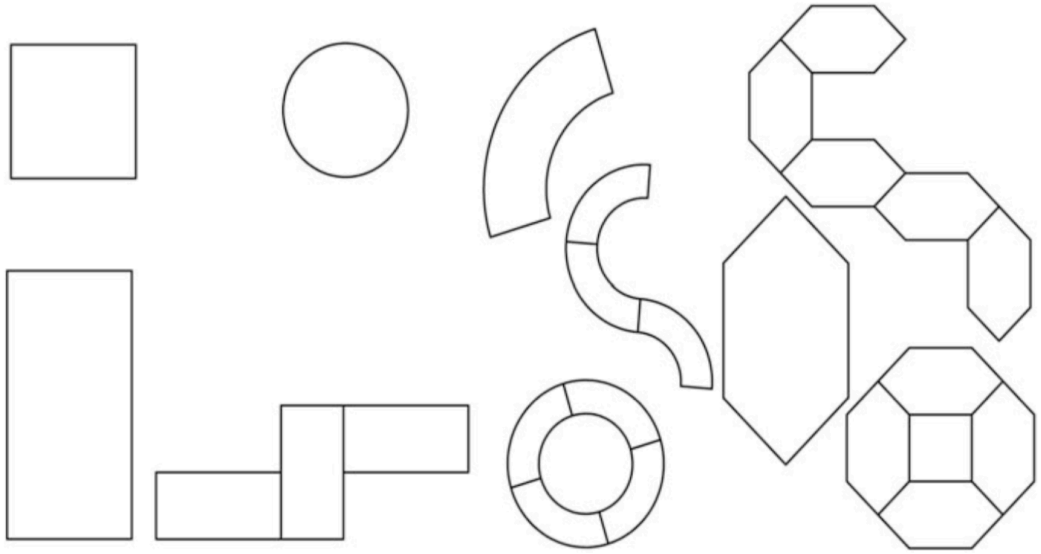


Figure 2.4. 7

Examples of the shapes of top surfaces of tables and possibilities of their connection furniture.

2.4.5 Upholstered Furniture

Definition

Upholstered furniture belongs to a group of products of complex structure and a multifaceted manufacturing process

Characteristic of Upholstered Furniture

Upholstered furniture is products of linear, surface and volume structure. Among the large group of elements of an upholstered furniture piece, we distinguish:

- main element, without which the furniture piece cannot provide the necessary stiffness, strength and reliability (e.g. the rail of an upholstery frame),
- complementary element, without which the product does not meet the expected usability functions (e.g. the foam inserts of the seat, the bottom of a container) and
- compensatory element, which can improve the quality of the bearing structure (e.g. an additional rail of the frame, additional supports and bars).

Upholstered Furniture		
Definition	Upholstered furniture belongs to a group of products of complex structure and a multifaceted manufacturing process Upholstered furniture is products of linear, surface and volume structure.	
Main element	Definition	Provide the necessary stiffness, strength and reliability
	Typical case	The rail of an upholstery frame
Complementary element	Definition	Meet the expected usability functions
	Typical case	The foam insert of the seat, the bottom of a container
Compensatory element	Definition	Improve the quality of the bearing structure
	Typical case	An additional rail of the frame, additional supports and bars

Table 2.4. 19

For functional reasons, upholstered furniture can be divided into three groups (Table2.4.20):

- for sitting: tabourets, chairs, armchairs, benches, sofas, couches and corner sofas
- for reclining: couches, beds, lounges, chaise lounges and mattresses
- for sitting and reclining: sofa, couches, sofas with a reclining function and corner sofas with a reclining function

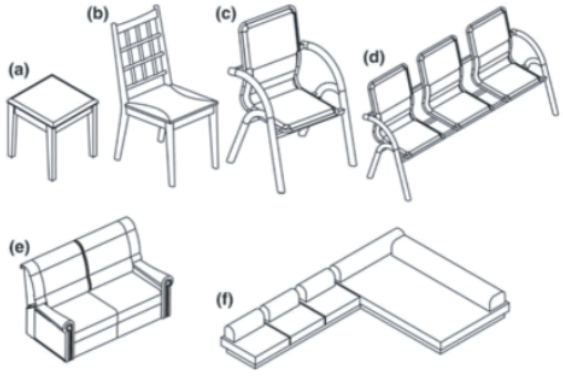
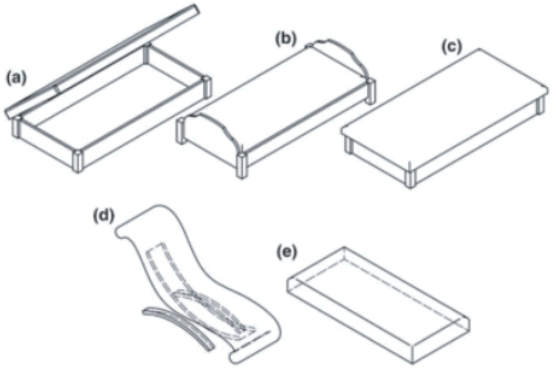
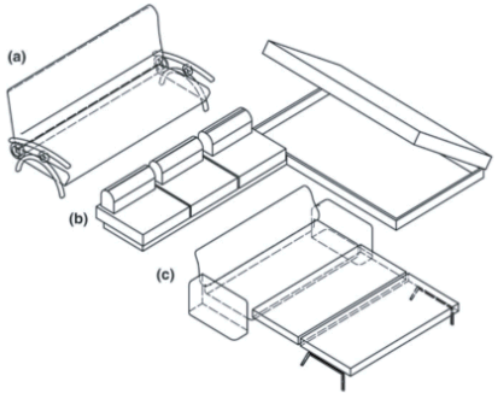
For sitting	
	(a) Tabourets (b) Chairs (c) Armchairs (d) Benches (e) Sofas (f) Corner sofas
For reclining	
	(a) Couches (b) Beds (c) Lounges (d) Chaise lounges (e) Mattresses
For sitting and reclining	
	(a) Sofa (b) Couches (c) Sofas with a reclining function (d) Corner sofas with a reclining function

Table2.4. 20

In upholstered furniture, the following elements are distinguished:

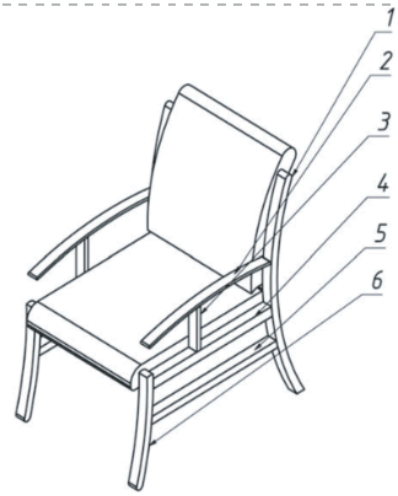
Strip	Acting as a slider, sup- porter, resistant, connector, etc., sliding strip, thickening strip, bearing strip, supporting strip, etc.,
Connector	A type of curve-shaped bar in bent furniture,
Bar	Constituting additional strengthening of a structural connection, longitudinal, transverse, etc.,
Leg	Back or front leg,
Support leg	Fulfilling the function of a back leg and support of the backrest simultaneously A bent element in the shape of an inverted U, playing the role of two support legs connected from the top in bent furniture for sitting constituting the primary horizontal structure , frontal, side, rear, longitudinal or transverse rail
Arch	a bent element in one or a few planes of an open circumference, usually constituting
Panel	strengthening of connections at the base of bent skeletal furniture, the plate element filling the space between the rails of the frame,
Armrest support	Armrest support
Armrest	an element constituting the support of arms in skeletal and upholstered furniture for sitting,
Shelf	loosely arranged horizontal board element for placing various objects,
Semi-rim	an open circumference, in the shape of the letter U, constituting the strengthening of connections
Post	the element that constitutes vertical reinforcement or filling in the skeleton and
Muntin	filling a particular space in an openwork manner

Table2.4. 21

Subassemblages and assemblages	
Side	The side limitation, armchair side, couch side and bed side
Bed	Upholstered assemblage or subassemblage for reclining
Mattress	Type of cushion acting as a bed, the mattress can have one, two, or more parts
Backrest	Backrest
Case module	An assemblage of several cases joined together
Headrest	Headrest
Base	Base
Cushion	Constituting a loosely inserted bed, seat,rest, etc
Armrest module	In skeletal furniture usually built from an armrest and support
Frame	Consisting of connected rails, fulfilling the bearing function, side frames, door frames, etc
Sitting frame	Constitutes the main structural connection of the seat
Seat	Seat
Chest	e.g. a chest for bedlinen
Frame	Subcomponent of a skeletal structure which is a kind of base
Front head	Constituting a fixed external constraint, reclining from the side of the user's head
Rear head	Constituting a fixed external constraint, reclining—from the side of the user's legs
Skeleton	Composed of structurally bound beam elements, rod elements, pipe elements, etc

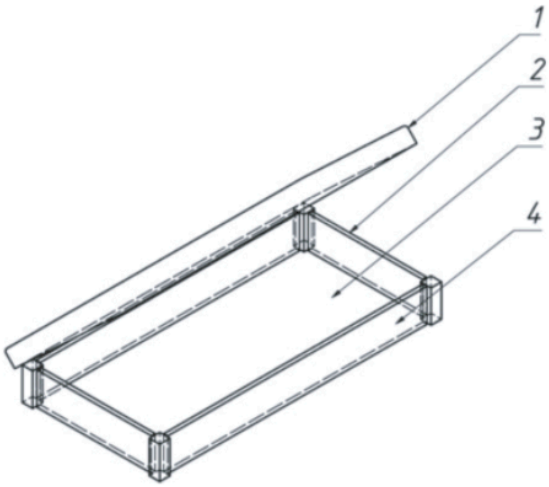
Table2.4. 22

Elements of upholstered furniture— armchair



1	support leg	2	armrest	3	armrest support	4	horizontal rail	5	rail
6	front leg								

Elements of upholstered furniture—couch



1	mattress	2	bedside short	3	bottom of the container	4	bedside long		

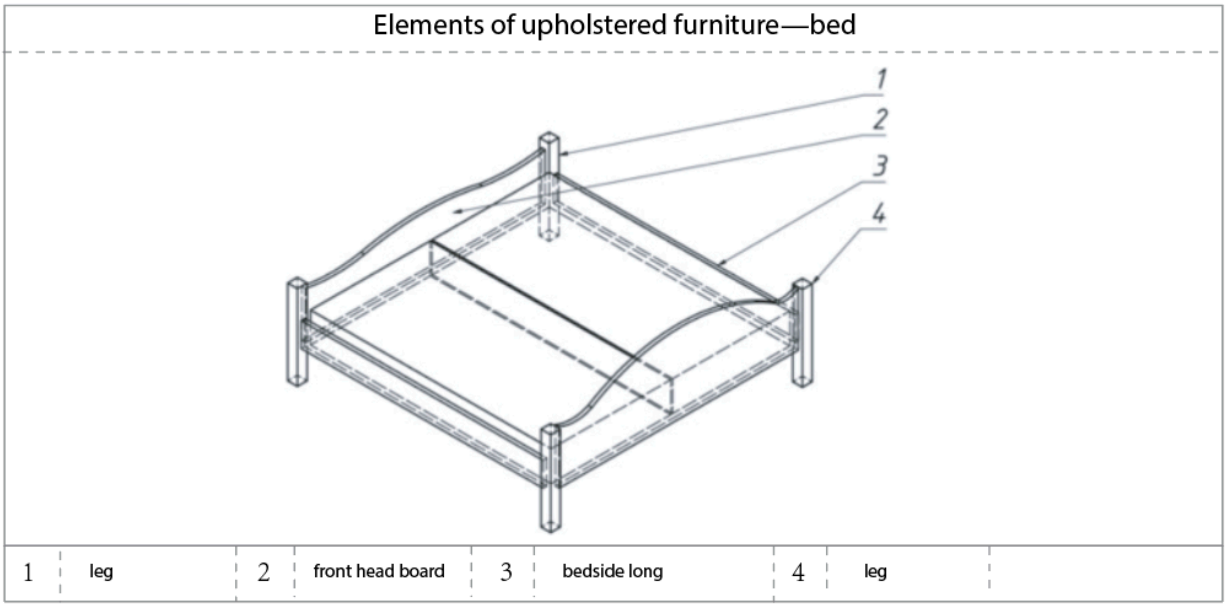


Table2.4. 23

Construction of upholstery furniture

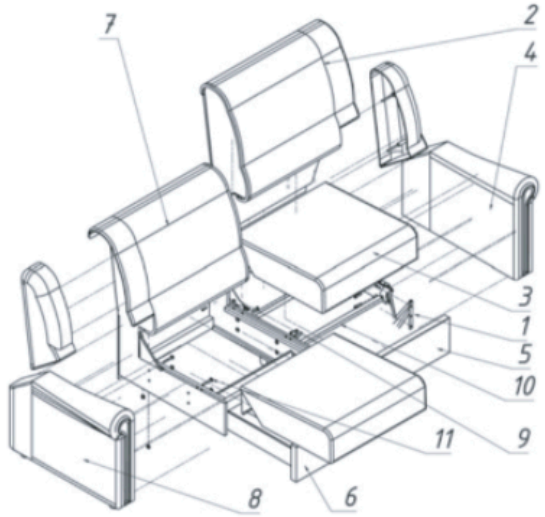
A typical construction of upholstered furniture intended for sleeping and/or relaxing consists of

- a set of foam pieces glued to the frame,
- a frame,
- a mattress assemblage or seat made of layers:
    - – support and base,
    - – spring (elastic) and – lining,
- a cover being the tapestry layer of the mattress or seat.

Construction of upholstery furniture

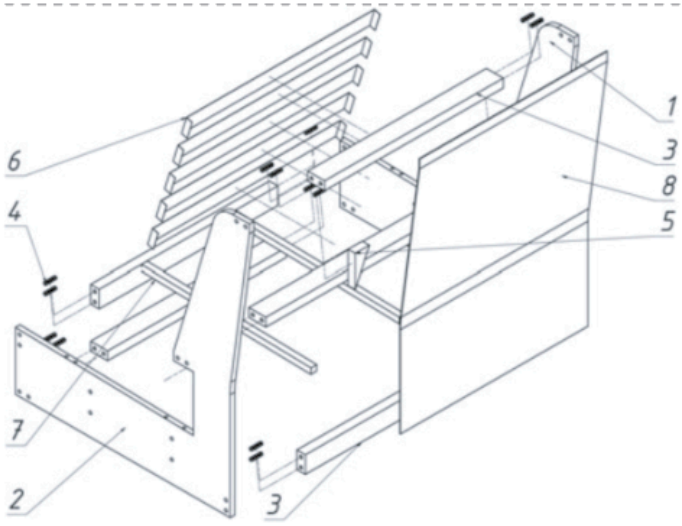
Table2.4.24 show the frame structure of a seat backrest assemblage and side of a single-person armchair. As can be seen, some of the construction elements have been connected using dowel joints. In industrial practice, however, inserted staple-type connections are mostly used.

Construction of upholstery furniture



1	footrest slide mechanism	2	backrest	3	seat	4	side	5	front of the footrest
6	front of the drawer	7	backrest	8	side	9	bolt	10	transverse rod
11	bolt								

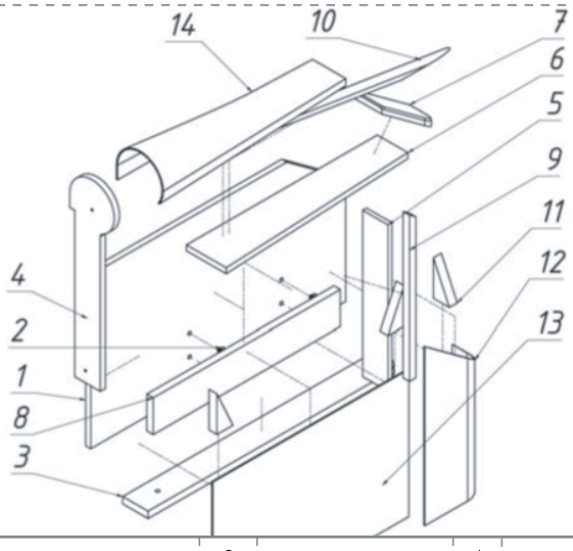
Construction of seat backrest assemblage of a single-person armchair



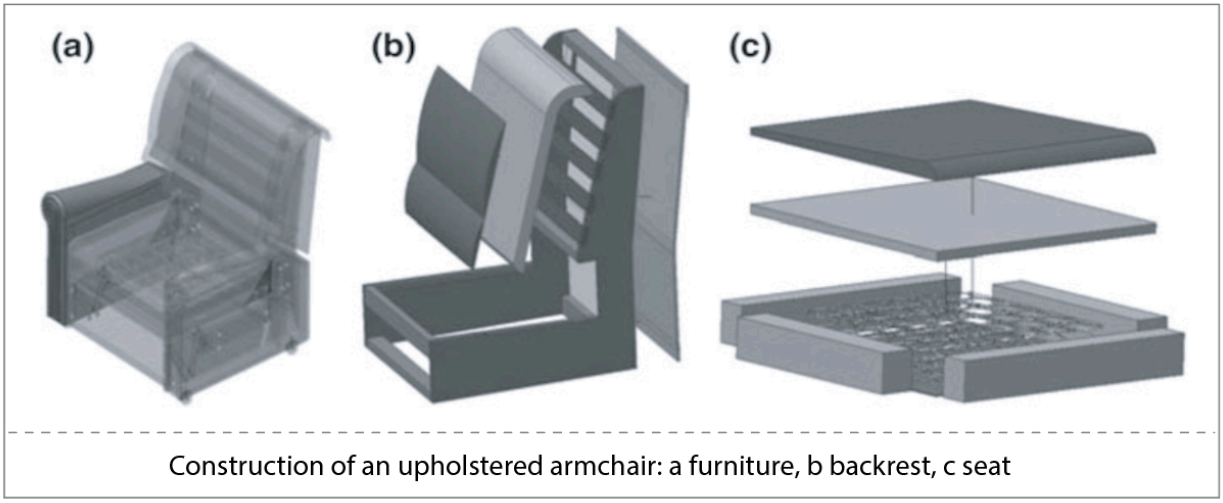
1	side	2	side	3	ransverse joining skirt	4	dowel connectors	5	supporting block
6	upholstery belts	7	longitudinal joining skirt	8	upholstery cardboard				

Table2.4. 24

Construction of side of an armchair



1	side unit	2	blind nut	3	baseboard	4	overlay board	5	rear sideboard
6	armrest board	7	bevel board	8	supporting sideboard	9	vertical skirt	10	slant armrest board
11	supporting block	12	curve cardboard unit	13	side cardboard unit	14	armrest cardboard unit		



Construction of an upholstered armchair: a furniture, b backrest, c seat

Table2.4. 25

2.4.6 Furniture Joints

The construction of a furniture piece is done by creating appropriate bonds between its particular elements, subassemblages and assemblages. Choosing the right kind of joints for the designed furniture piece depends mainly on the type and form of the construction, but it should always lead to construction that ensures its high stiffness and strength, and ease of realization technologically.

2.4.6.1 Division of furniture joints

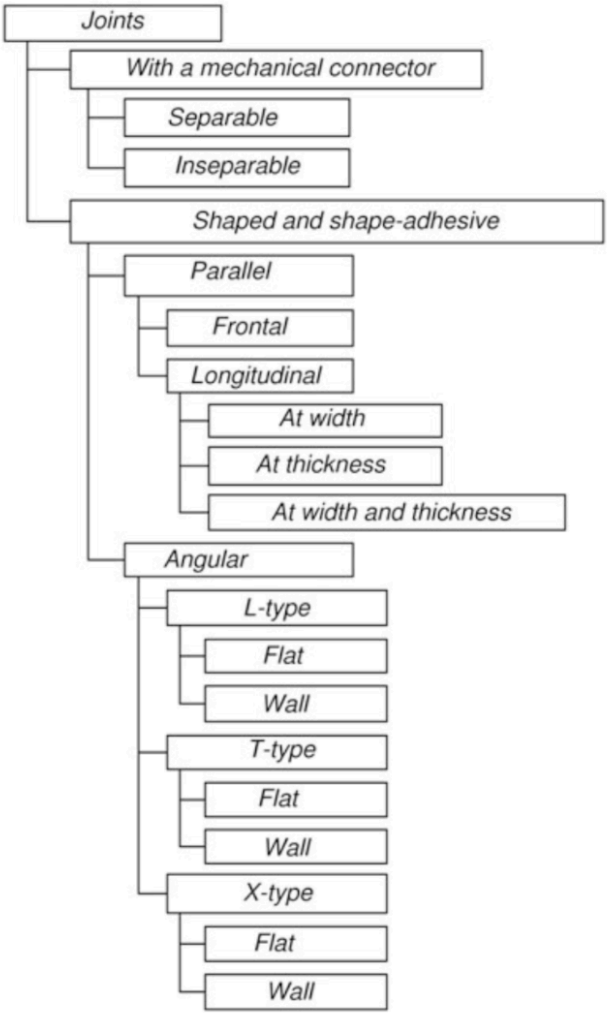


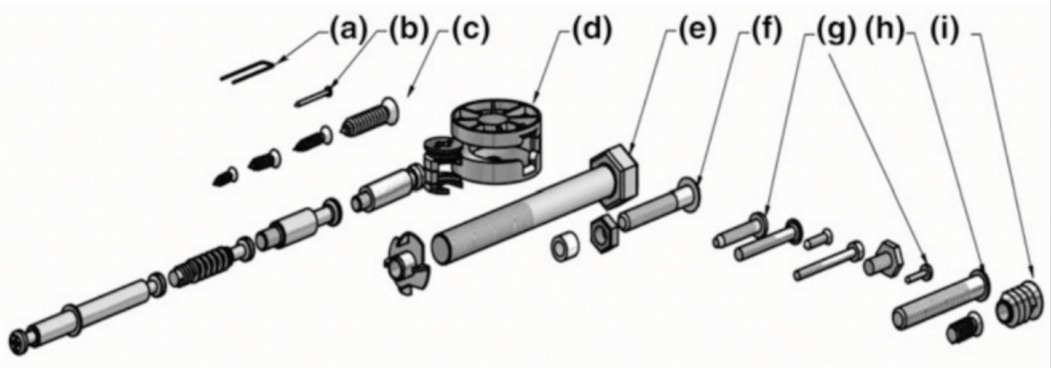
Table2.4. 26 (Smardzewski, 2015, p. 236)

Joints with mechanical connectors form a large group of metal and plastic separable and inseparable structural nodes. Currently, the most representative can be considered joints with connectors such as staples, nails, bolts, screws, hooks and eccentric joints.

Shaped and shape-adhesive joints contain shaped interfaces in specific parts of furniture elements, which ensure their independent connection without or with the use of glue as a connector. Of course, shape-adhesive joints prevail in this group. Formed and perfected for generations, they provide for the inseparability of the construction, and, therefore, a satisfactory stiffness and strength. Due to the mutual system of joined elements, these joints are applied in the design of skeletal furniture, case furniture and bearing structures of upholstered furniture.

2.4.6.2Joints with Mechanical Connectors

Mechanical connectors



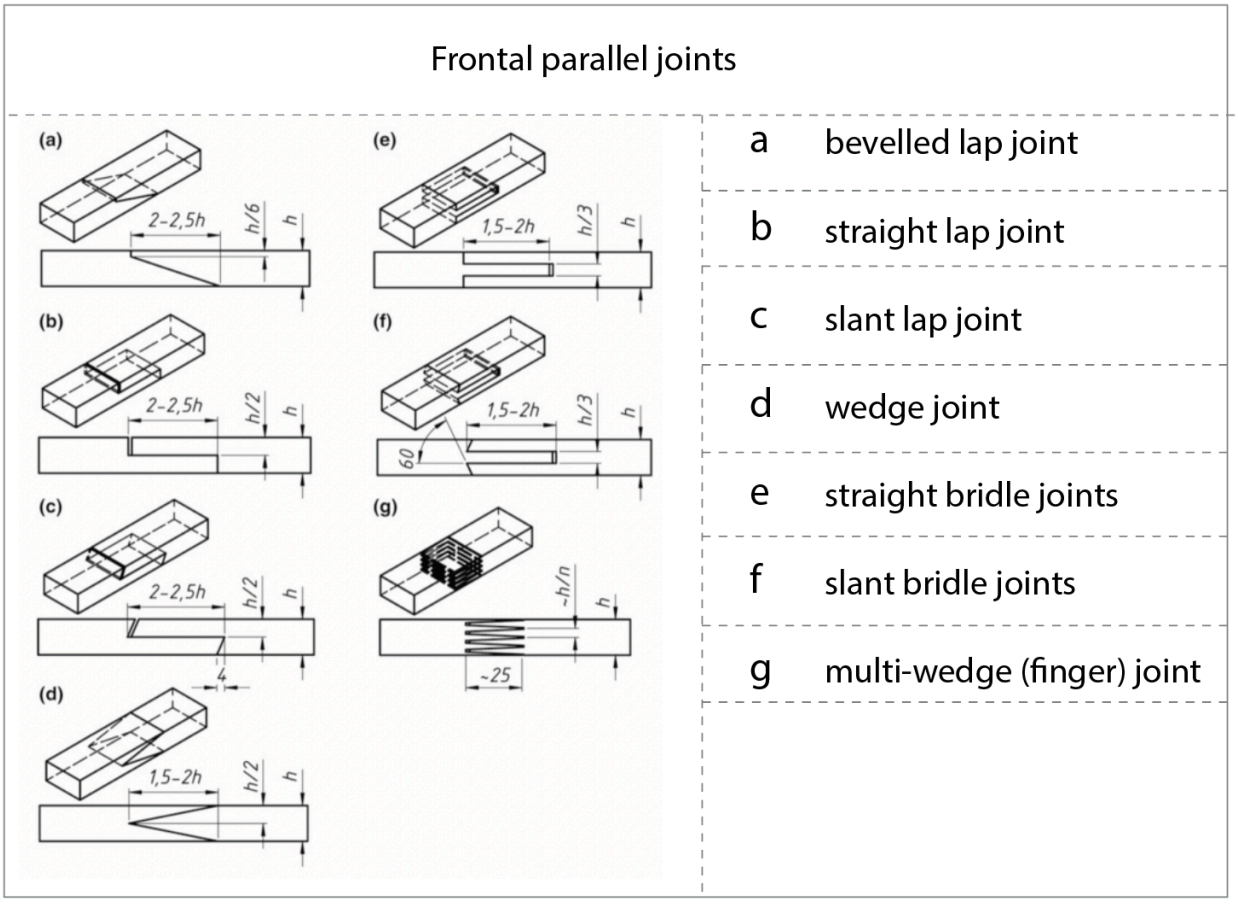
a	staple	e	screw with blind nut
b	nail	f	screw with nut
c	screws for wood	g	screws for metal
d	eccentric joints—box with eccentric joint, core	h	confirmat screw
		i	screws for chipboards

Table2.4. 27 Joints with Mechanical Connectors (Smardzewski, 2015, p 237)

2.4.6.3 Shaped and Shape-Adhesive Joints

Frontal Parallel Joints

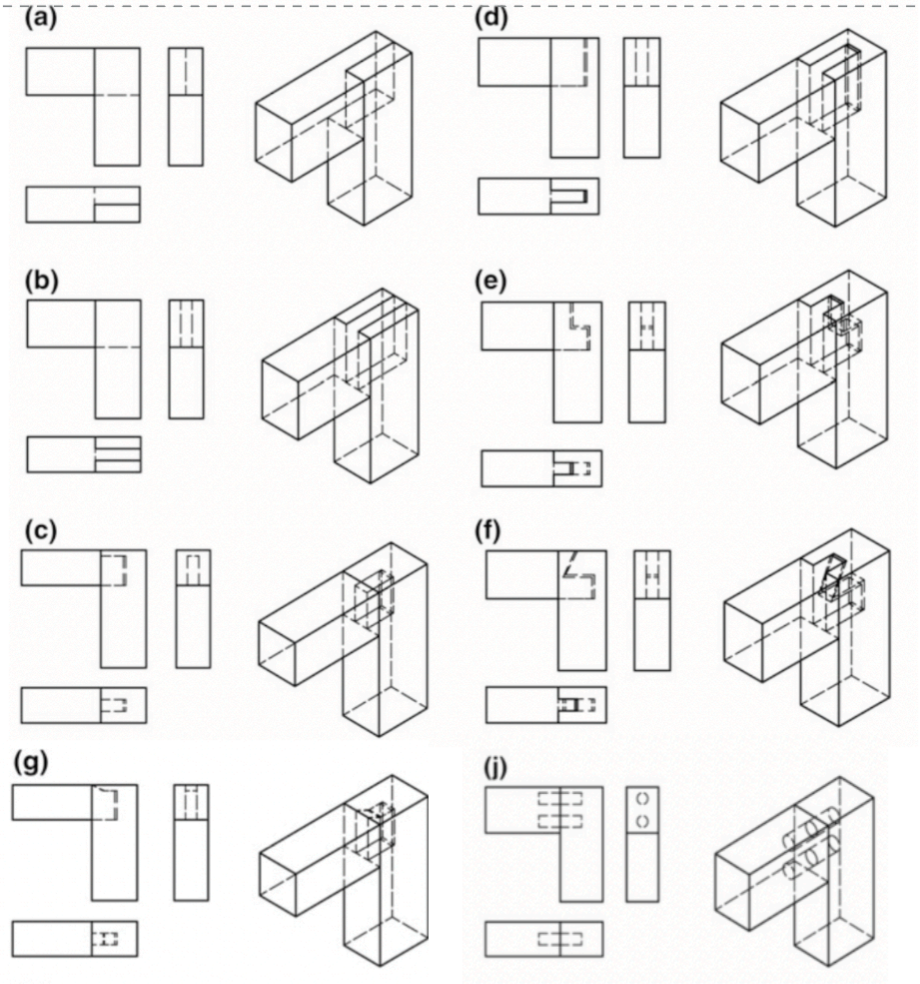
Frontal parallel joints are used to increase the length of beam elements.



Flat L-Type Joints

Flat L-type joints are used to connect beam elements at an angle. In regard to the value of the slant angle of adjoining elements, we distinguish perpendicular flat L-type joints (Table2.4 28) and slant flat L-type joints (Table2.4 29).

Perpendicular flat L-type joints



a straight lap joint

b single through mortise and tenon joint

c single covered mortise and tenon joint

d single semi-covered mortise and tenon joint

e, f single separated mortise and tenon joint
perpendicular flat L-type joints

g single separated mortise and tenon joint

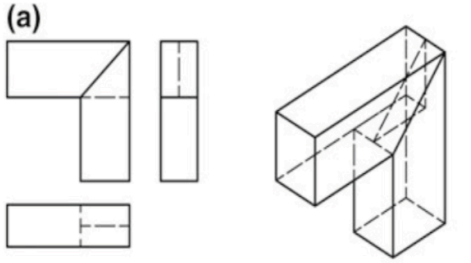
h double through mortise and tenon joint

i double semi-covered mortise and tenon joint

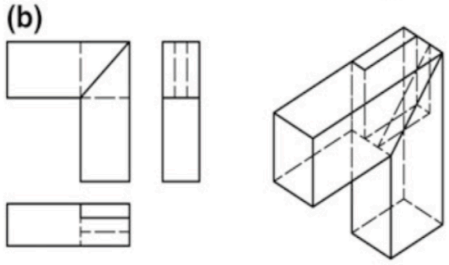
j double dowel joint

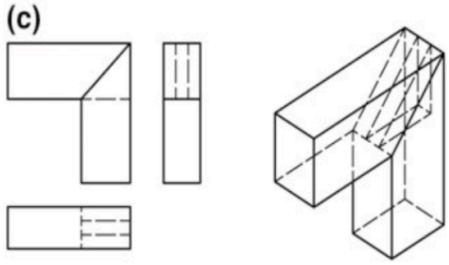
Table2.4. 28

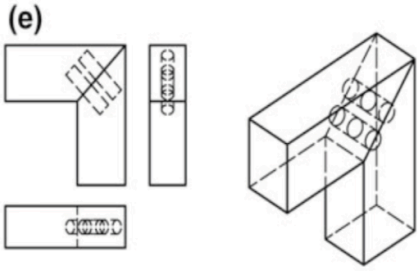
Slant flat L-type joints

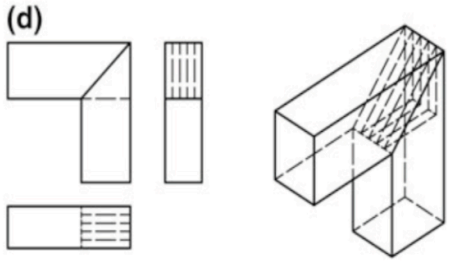


a	bevel lap joint
b	single bevel mortise and tenon joint
c	single bevel mortise and tenon joint
d	double bevel mortise and tenon joint
e	double bevel dowel joint
f	covered bevel mortise and tenon joint









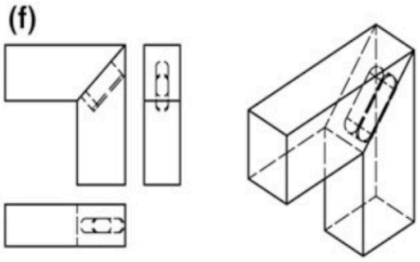
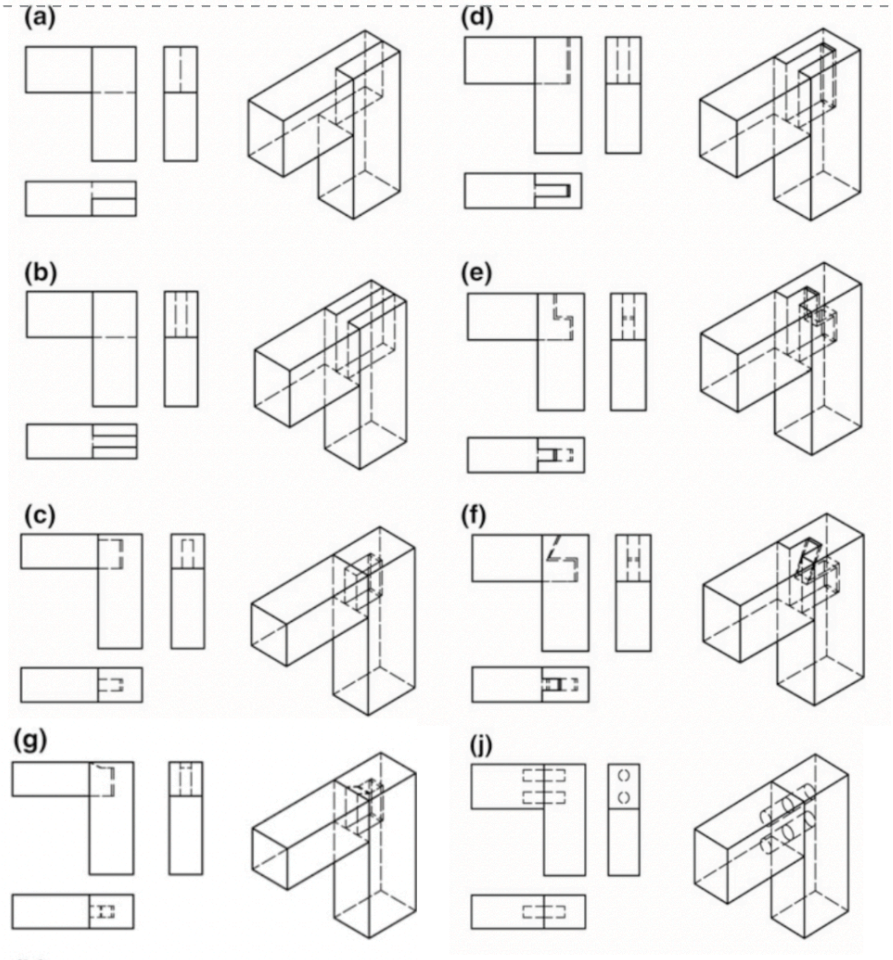


Table2.4. 29

Flat T-Type Joints

Flat T-type joints in furniture are used for connecting bearing structure elements of case and skeletal furniture.

Perpendicular flat L-type joints



a straight lap joint

b single through mortise and tenon joint

c single covered mortise and tenon joint

d single semi-covered mortise and tenon joint

e, f single separated mortise and tenon joint
perpendicular flat L-type joints

g single separated mortise and tenon joint

h double through mortise and tenon joint

i double semi-covered mortise and tenon joint

j double dowel joint

Table2.4. 30

Flat X-Type Joints

Flat X-type joints dominate mainly in joinery products. In furniture, they are used occasionally to connect decorative elements

Plate Frontal Parallel Joints

Plate frontal parallel joints are used to increase the length of board elements. Joints with dowel connectors or biscuit joints are most commonly used here.

Plate Longitudinal Parallel Joints

Plate longitudinal parallel joints are used to increase the width of board elements. They are usually used in the production of table worktops, bottoms, top surfaces and side walls of case furniture.

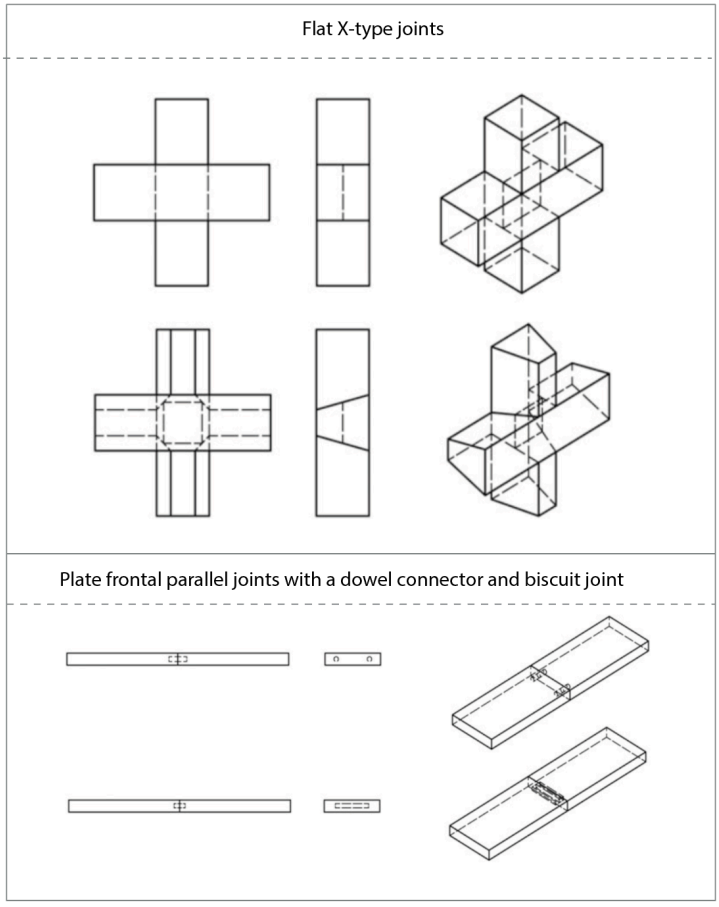


Table2.4. 31 Table2.4. 32

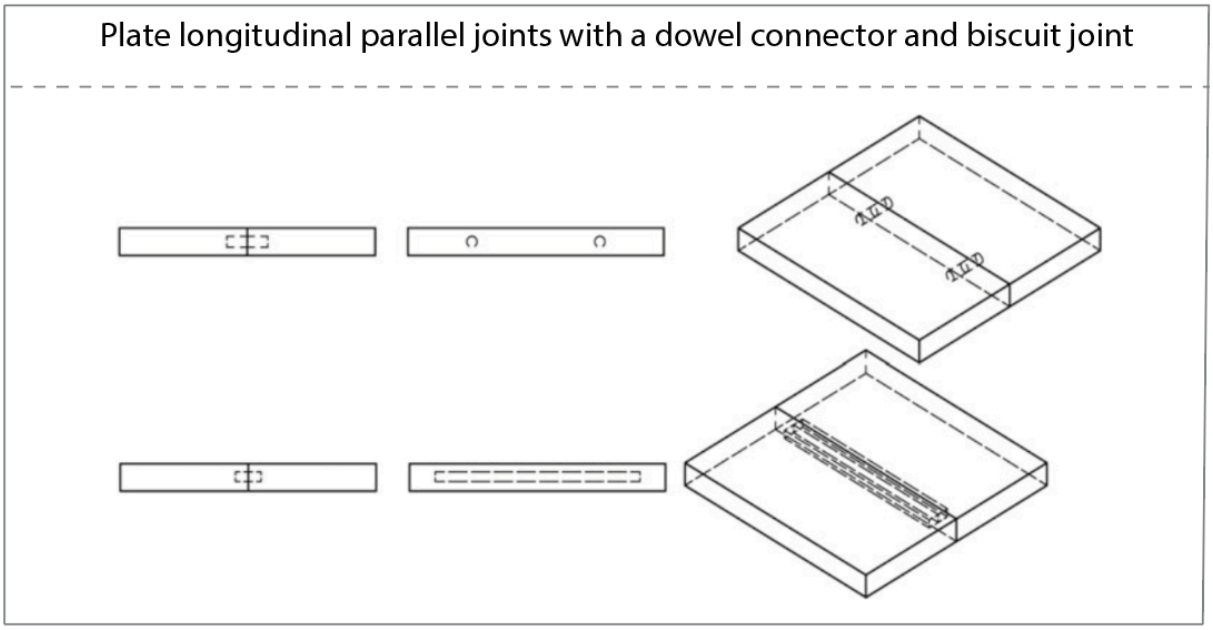
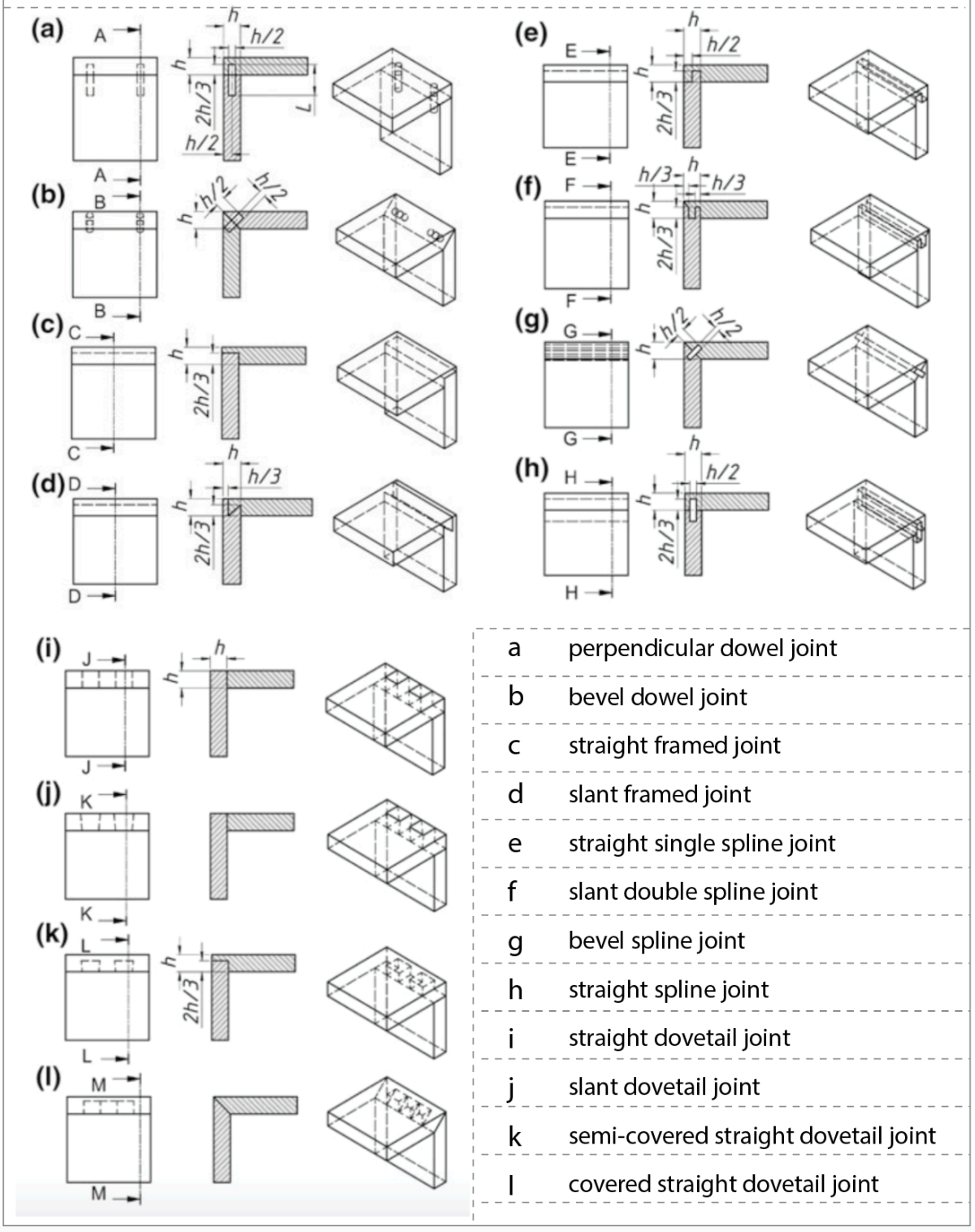


Table2.4. 33

Plate L-Type Joints

Plate L-type joints are used to connect board elements at an angle (Table2.4 34).

Plate L-type joints



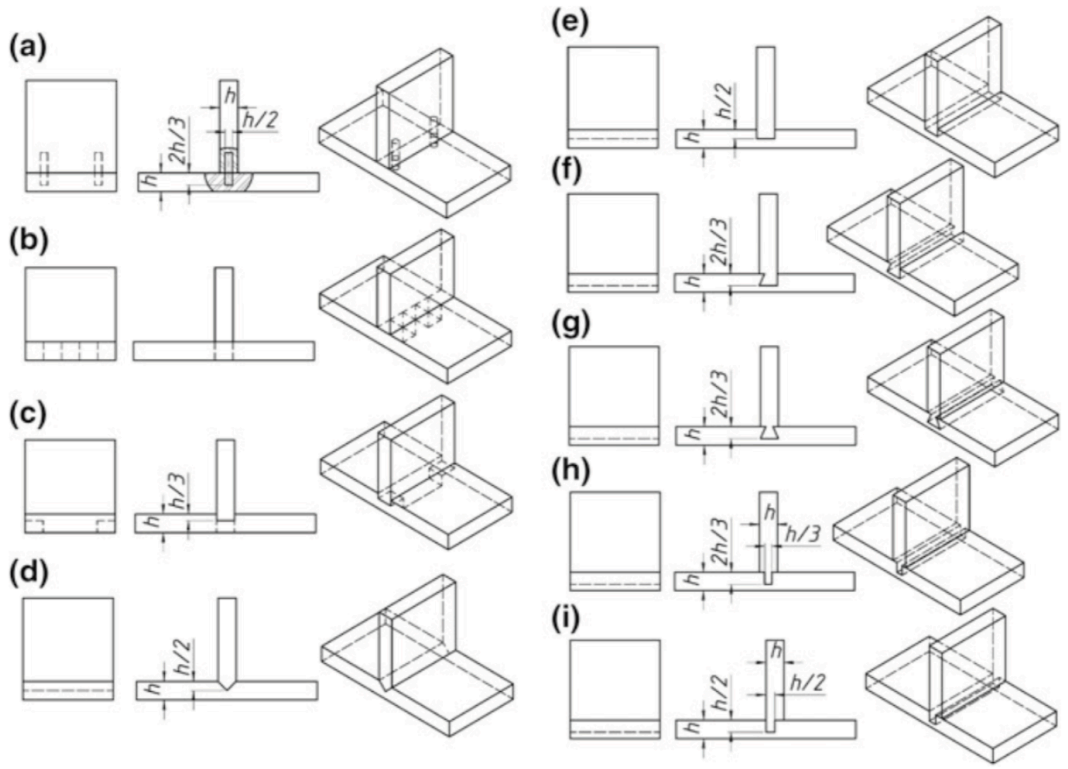
a	perpendicular dowel joint
b	bevel dowel joint
c	straight framed joint
d	slant framed joint
e	straight single spline joint
f	slant double spline joint
g	bevel spline joint
h	straight spline joint
i	straight dovetail joint
j	slant dovetail joint
k	semi-covered straight dovetail joint
l	covered straight dovetail joint

Table2.4.34

Plate T-Type Joints

Plate T-type joints are used to connect board elements of the bodies of case furniture, in particular side walls, bottom boards and top surfaces with horizontal and vertical elements, as well as connecting elements between one another (Table 2.4.35).

Plate L-type joints



a	straight dowel joint	e	full spline joint
b	regular mortise and tenon joint	f	fin unilateral joint
c	full spline mortise and tenon joint	g	fin bilateral joint
d	sharp spline joint	h	spline joint
		i	spline framed joint

Table 2.4.35

Plate X-Type Joints

Plate X-type joints occur only in places of joining of elements and interior walls of the bodies of case furniture, as well as places where honeycomb mesh fills of woodwork boards meet (Table 2.4.36)

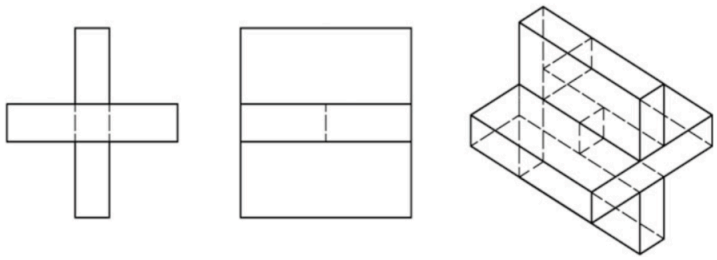
Plate X-type joints


Table 2.4.36

2.4.7 Furniture materials

In terms of materials, this thesis will mainly focus on the visual effect of the materials. The visual properties of the material are mainly reflected in color, pattern, lustrousness and texture.

Color

Color is the most attractive element. The color of furniture materials is divided into natural color and industrial color.

Natural materials such as wood, stone, bamboo and rattan have unique and rich colors, overall giving warm and affectionate feelings. In order to protect this natural color, transparent lacquer is often used in production. Industrial colors can be further divided into surface-added colors and processing colors produced in processing engineering.

The surface-added colors can be divided into paint color, decorative paper veneer color, and electroplated spray color. Processing colors refer to the color formed by adding dye to the

material processing process, such as textile, leather, plastic, paper, colored glass, artificial stone, and the like.

The color of the industrial color is ever-changing and can be adjusted according to needs, but it lacks the natural feeling and gives a modern impression. In addition to producing this fashionable and rich color, industrial color can also produce natural original styles such as hemp fabric and rattan carbonized coffee color. In addition to the decorative effect, the color can be refined to highlight the function of furniture.

Pattern

The pattern is a form of art that is visually pleasing and partially functional. It is obtained by sorting, processing, and changing based on the natural image of life. The patterns mainly include animal and plant patterns, landscape patterns, ethnic patterns and geometric patterns. The geometric pattern of the rules gives a sense of integrity, fullness and stability; the dense, overlapping, continuous and irregular geometric patterns give a sense of casualness, liveliness and variation. Animal and plant patterns through realism, exaggeration, simplification, etc. give people a luxurious or simple, rough or delicate, plump or simple expression. The colorful, richly styled ethnic-inspired motifs bring a rustic, fresh or refined look.

Lustrousness

Lustrousness is an important part of evaluating the appearance quality of materials. Lustrousness is the degree of light that a material exhibits on a surface under certain background and light conditions. Generally, the smoother the fabric and the higher the color purity, the stronger the gloss that can be produced in a proper light environment, which is a strong stimulus to people. The bright, smooth surface reflects the dazzling light, and the rough surface absorbs light.

Texture

Texture refers to the natural material itself or artificially designed crisscross, rugged, rough and smooth texture structure. The texture is the representation of the form, can express the characteristics of the object from the outside to the inside, and have the ability to give the product great artistic expression. Any material surface has its specific texture morphology, and different textures will cause different emotional responses in both physical and psychological terms. The texture can be divided into visual texture and tactile texture. The influence of visual texture is mainly reflected in shape orientation, color and glossiness. The tactile texture is mainly reflected in roughness, hardness, and density. The visual texture is affected by color and light. The higher the purity and lightness of color, the stronger the color expression; thus, this phenomenon will reduce the perception of texture. The use of different lighting methods can also enhance or weaken the texture effect.

The texture is divided into natural texture and artificial texture. Wood and stone have a natural texture that cannot be copied, and the texture of textiles, plastics and glass can be transformed by artificial behavior.

2.4.8 Quality of furniture

Each piece of furniture, as an object of applied arts, in a long-life cycle usually passes over two stages: the stage of development, i.e. design and manufacture, and the stage of use, i.e. fulfilling needs. In the first stage, the designer and the manufacturer can only in theory or on a small sample evaluate the quality of the modelled and manufactured products. The real assessment of the quality of the furniture piece takes place only during everyday use by dozens or hundreds of users. Therefore, furniture should be evaluated from two points of view:

• Manufacturing and

• Requirements of the user

Among the manufacturing characteristics, construction, technological and economical values are distinguished, which affect both the aesthetics and the safety of using furniture and the technical cost (as low as possible) of manufacturing (Smardzewski, 2015, p. 65).

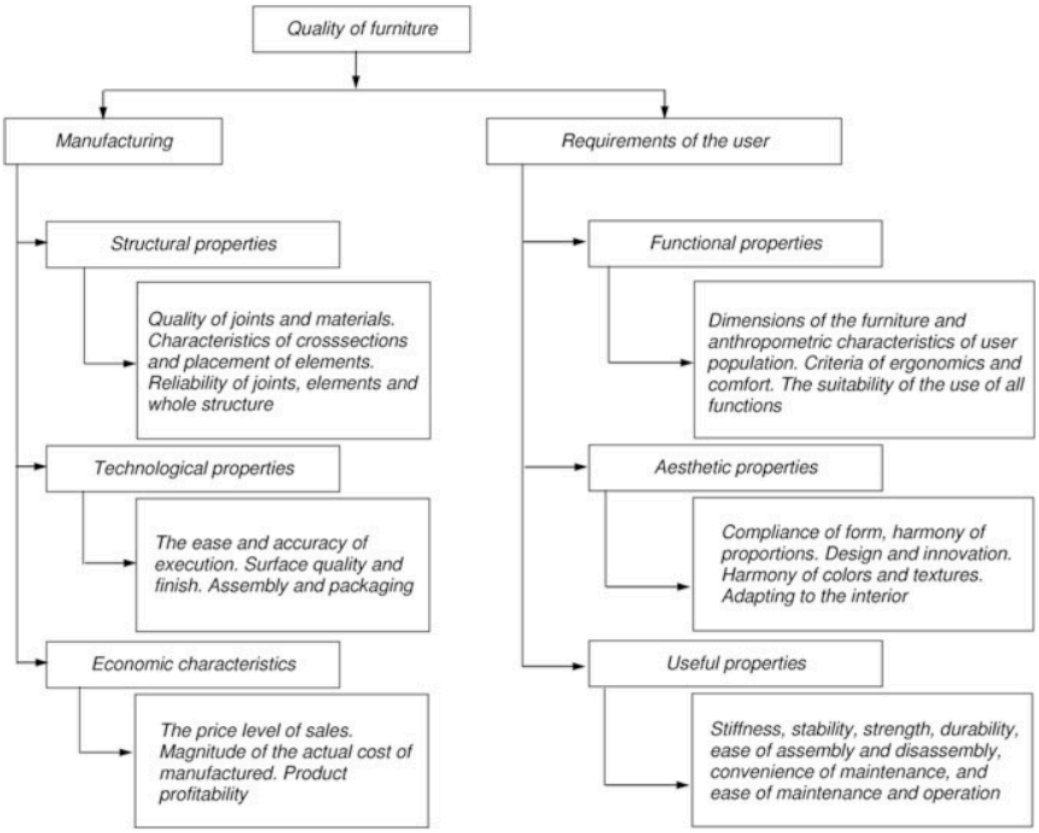


Figure 2.4. 8

2.4.9 Design process

The development of the proper structural version of furniture, ensuring durable and safe use, is one of the components of the design process (Fig2.4.9). Certainly, however, designing the function of furniture has a unique practical importance as it provides the most effective possible fulfilment of the assumed functions of use. The purpose of aesthetic activities is shaping the

proportions and spatial forms of furniture and the choice of surface color, texture and drawing to the satisfaction of the most sensitive tastes of the potential user.

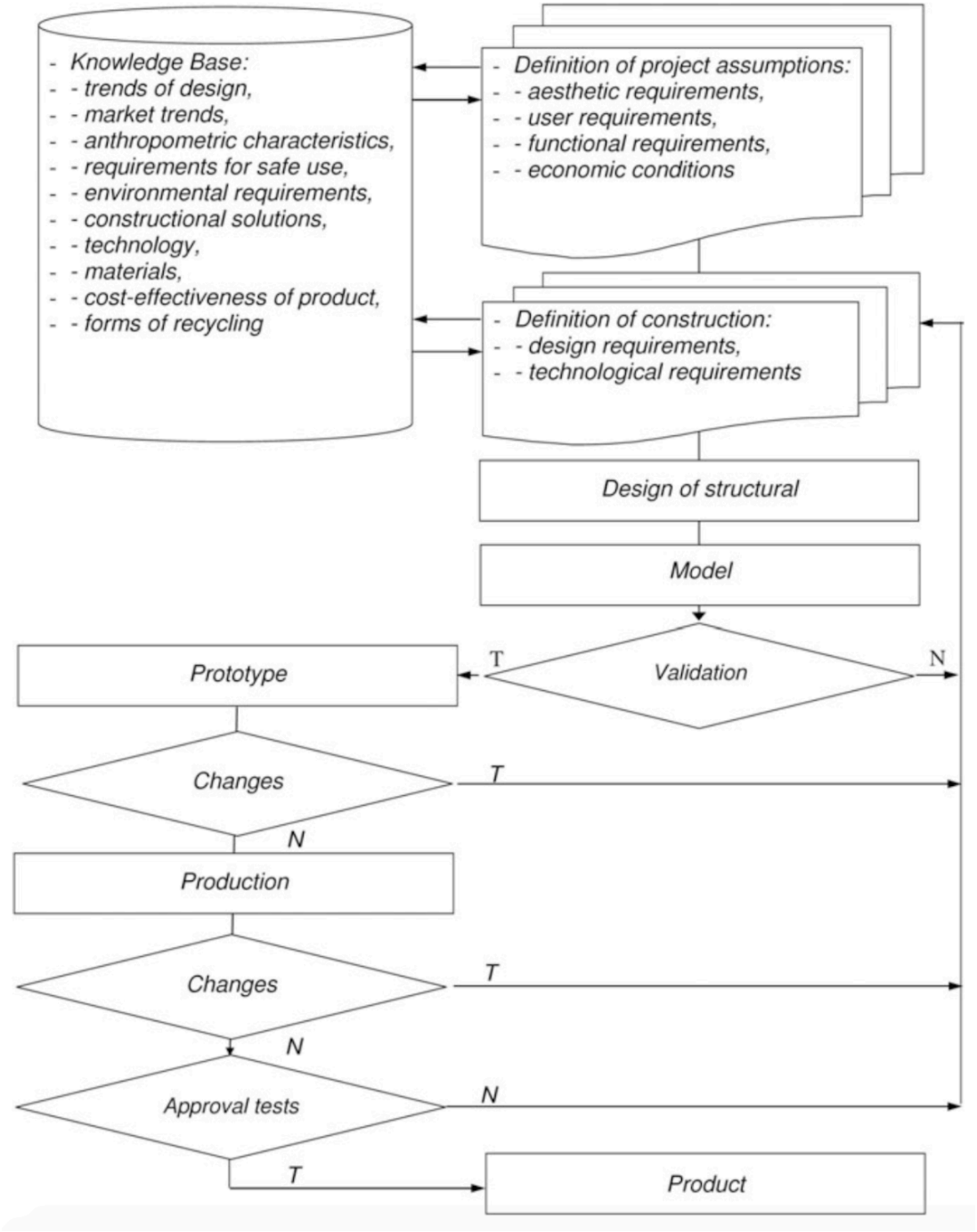


Figure 2.4. 9

2.5 Mass customization

2.5.1 Definition

Piller(2007) thus defines mass customization: "Mass customization refers to a customer co-design process of products and services which meets the needs of each individual customer with regard to certain product features" (p.8).

Joseph Pine (1993) define mass customization as "developing, producing, marketing and delivering affordable goods, and services with enough variety and customization that nearly everyone finds exactly what they want. What one needs, when one needs it".

2.5.2 The Capabilities of Mass Customization

If company want to profit from mass customization, there are three fundamental groups of capabilities, called Solution Space Development, Robust Value Chain Design, and Choice Simplification (Frank, 2010, p.5).

- **Differentiating need:** First and foremost, a company seeking to adopt mass customization has to be able to understand what the idiosyncratic needs of its customers are. This is in contrast to the approach of a mass producer, where the company focuses on identifying "central tendencies" among its customers' needs, and targets them with a limited number of standard products. Conversely, a mass customizer has to identify the product attributes along which customer needs diverge the most.
- **Robust Process Design:** A second critical requirement for mass customization is related to the relative performance of the value chain. Specifically, it is crucial that the increased variability in customers' requirements does not lead to significant deterioration in the firm's operations and supply chain. This can be achieved through robust value chain

design – defined as the capability to reuse or recombine existing organizational and value chain resources to fulfill differentiated customer's needs. With robust process design customized solutions can be delivered with near mass production efficiency and reliability.

Choice Navigation: Finally, the firm must be able to support customers in identifying their own problems and solutions, while minimizing complexity and burden of choice. When a customer is exposed to too many choices, the cognitive cost of evaluation can easily outweigh the increased utility from having more choices, creating the "paradox of choice": too many choices reduce customer value instead of increasing it (Huffman & Kahn 1998; Piller 2005). As such, offering more product choices can easily prompt customers to postpone or suspend their buying decisions, and, even more worryingly, to classify the vendor as difficult to deal with and hence undesirable. Therefore, the third requirement needed to ensure successful adoption of mass customization is the organizational capability to simplify the navigation of the company's product assortment. We call that choice simplification (Frank, 2010, p.5).

2.5.3 Examples of approaches to develop Mass customization capabilities

Table 2.5.1 summarizes some of the methods companies can apply when building these capabilities (Salvador, 2008).

Mass customization capability	Examples of approaches to develop Mass customization capabilities
Solution Space Development: *Capability to identify the product attributes along which customer needs mostly diverge*	**Innovation toolkits:** Software applications that can empower large pools of customers to translate their preferences into unique product variants by themselves, enabling each of them to highlight possibly unsatisfied needs **Outcome-driven innovation:** Methods to identify latent customer needs in an analytic way and to transfer those into product functionalities. **Customers experience intelligence:** Definition of adequate processes to continuously collect data on past customer transactions/ behaviors/ experiences and to translate this data into information on customer preferences
Robust Process Design: *Capability to reuse or re-combine existing organizational and value chain resources to fulfill a stream of differentiated customers needs*	**Flexible automation:** Using modern "digital" manufacturing technologies that enable high variance in operations at low switching cost. **Process modularity:** Reusing and recombining existing organizational and value-chain resources to fulfill differentiated customers' needs **Adaptive human capital:** People are a necessary element of a mass customization strategy, especially for their capacity to deal with new and ambiguous task.
Choice Navigation: *Support the customers in identifying their own solutions, while minimizing complexity and burden of choice*	**Assortment matching:** Negotiating the characteristics of an existing assortment with a model of the customers' needs in order to propose possible solutions to the customers without requiring significant effort and time in the search process **Fast-cycle trial-and-error learning in co-design toolkits:** Empower customers to build models of their own needs and to learn about appropriate solutions to their needs by interactively testing the match between these models and the available options. **Embedded configuration:** Developing smart products that "understand" how they should adapt to usage conditions and re-configure itself accordingly to a user profile.

Table 2.5 1: Three capabilities to make mass customization work

2.5.4 Examples of approaches to develop Mass customization capabilities

The concept of customization can be explained by considering the operational activities of a generic manufacturing enterprise: design, fabrication, assembly and distribution.

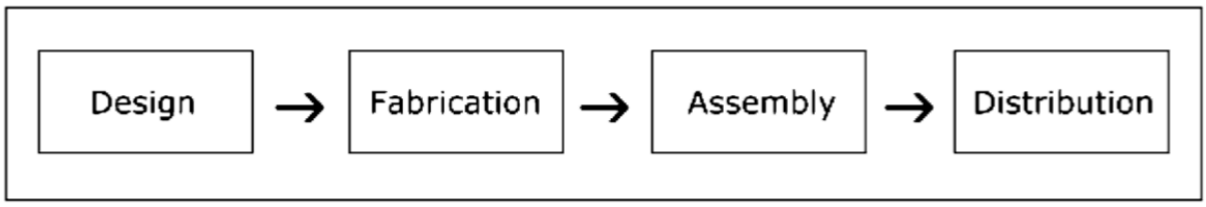


Figure2.5 1 Generic sequence of operational activities for a manufacturing company

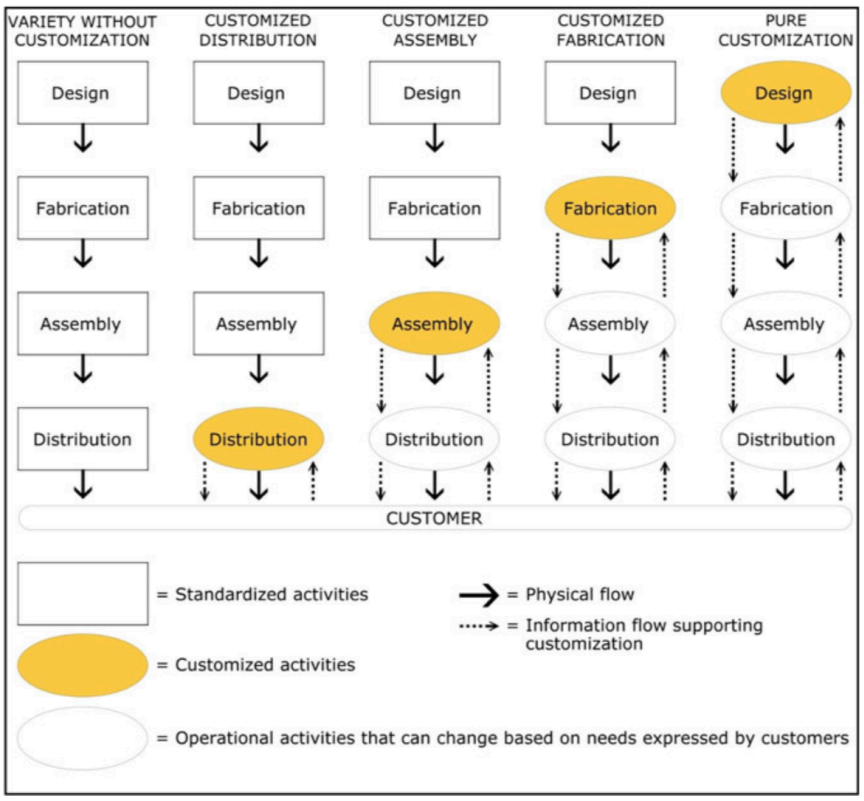


Table2.5 2 Scope of product configuration (Lampel,1996)

The classification of the five different types of customization shown in Fig 2.5.2 underlines the difference between product customization and product variety. The concept of customization is based on direct influence by the customer on one or more operational activities. Variety without customization means that the customer does not have the possibility to influence any of the operational activities design, fabrication, assembly or distribution. This means that the choice of the customer is limited and that he/she has to choose a given product of a defined variety offered by the companies.

Customized distribution means that the customer can only influence the distribution of the product.

In customized assembly customers influence the assembly activities. A perfect example is Dell, which offers its customers the opportunity to personalize a computer using prefabricated

components. Hence, the customer has no possibility to design the single parts or to influence the fabrication process, because at the moment when the customer customizes and orders his product, the single parts are already fabricated.

If a company offers customized fabrication then the customer's requirements directly influence the manufacturing activities. At present, the degree of personalization at the fabrication stage is limited because of technical and technological restrictions and only allow the customer to choose from a given list of options (Aichner, 2011).

2.6 Modular design

2.6.1 Definition

Modular design is a design technique that can be used to develop complex products using similar components. Components used in a modular product must have features that enable them to be coupled together to form a complex product. Modular design can be viewed as the process of producing units that perform discrete functions, then connecting the units together to provide a variety of functions. Modular design emphasizes the minimization of interactions between components, which will enable components to be designed and produced independently. Each component designed for modularity is supposed to support one or more functions. When components are structured together to form a product, they will support a larger or general function. This shows the importance of analyzing the product function and decomposing it into sub-functions that can be satisfied by different functional modules (Kamrani, 2002).

2.6.2 Modular design and mass customization

Modular design is one of the methods of mass customization. Modules are basic units for basic manufacturing. They are versatile and standardized, and can be assembled in a variety of different combinations to achieve product customization. The modular design is based on the functional analysis of different functions or functions with different performances and different

specifications in a certain range, and a series of functional modules are divided. By selecting and combining the modules, different products are formed to meet the requirements (Liu, 2008).

2.6.3 Categories of Modules

Production modules are designed based on production considerations alone and are independent of their function. Function modules can be c1assified based on the various types of functions reoccurring in a modular system that can be combined as sub-functions to implement the different overall function (Figure 2.6.1). These functions are basic, auxiliary, special, adaptive, and customer-specific functions (Kamrani, 2002, p.47).

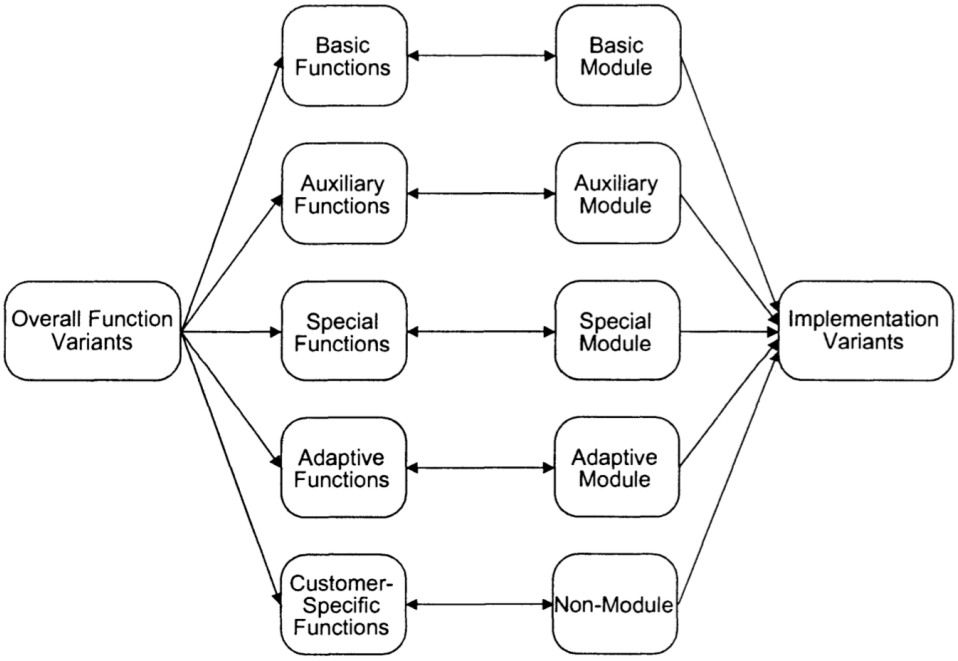


FIgure.2.6. 1 Function and Module Types

2.6.4 Design for Modularity Life Cycle

Modularity can apply to production systems, where it aims at building production systems from standardized modular machines. The fact that a wide diversity of production requirements exists has led to the introduction of a variety of production machinery and a lack of agreement on what the building blocks should be. This means that there are no standards for

modular machinery. In order to build a modular production system, production machinery must be classified into functional groups from which the selection of a modular production system can be made to respond to different production requirements.

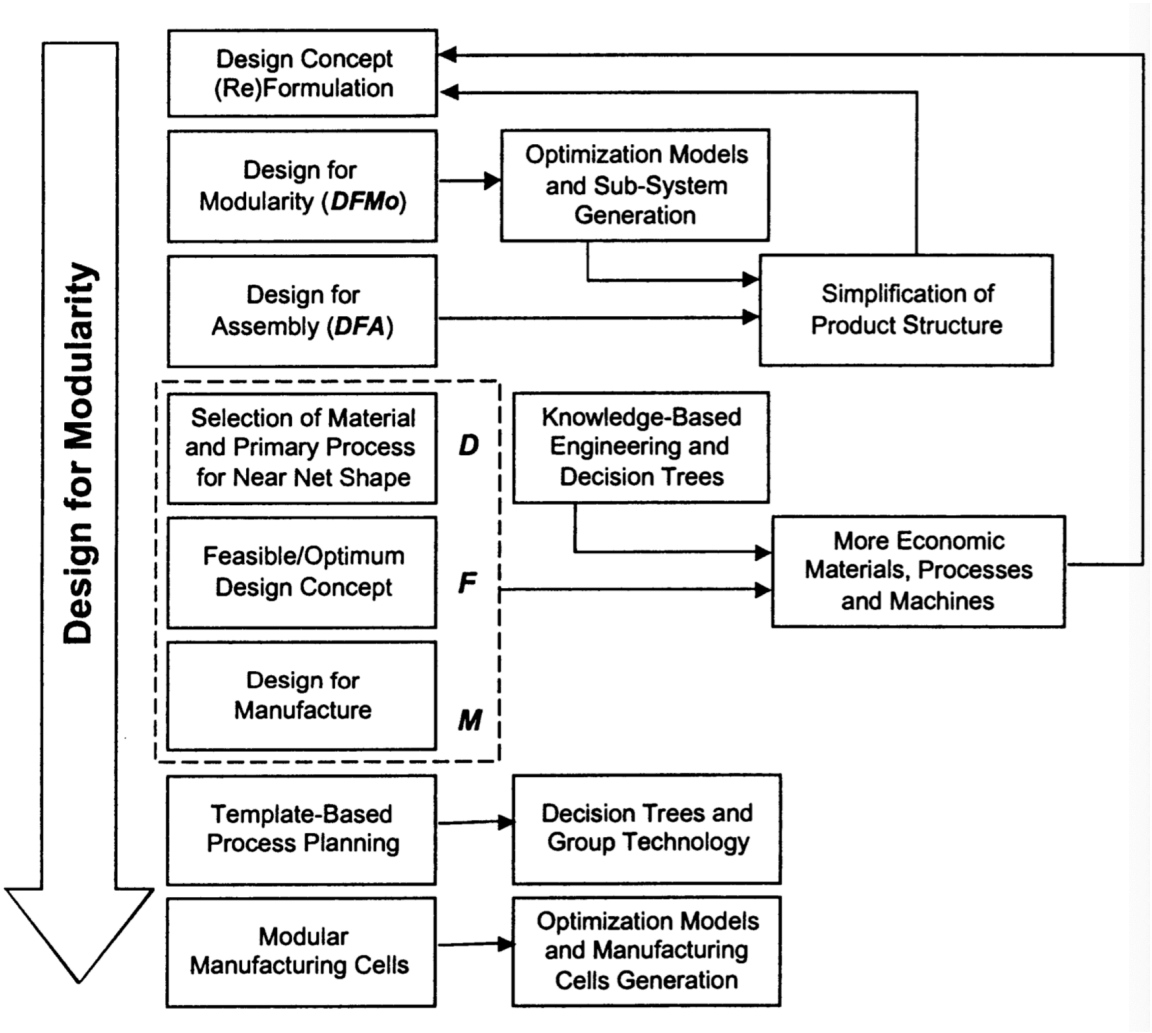


FIgure.2.6. 2 Design for Modularity Life Cycle

2.6.5 Generic product development process

A generic product development process can be constructed starting with needs recognition and ending with the marketing of a finished product. The major phases are illustrated

in Figure 2.6.3 (Ali K. Kamrani, 2002, p. 6).

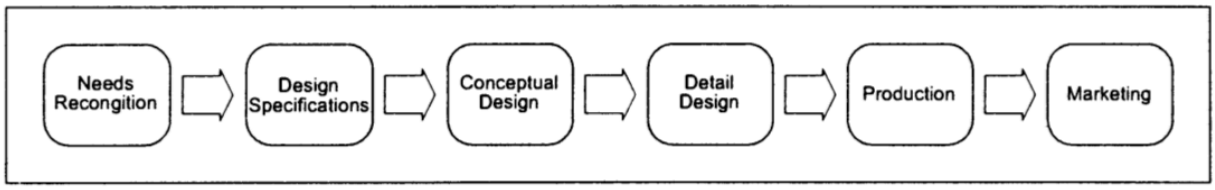


FIgure.2.6. 3 Product Development Process (Ali K. Kamrani, 2002)

2.6.6 Function- structure diagram

Product functional decomposition describes the product's overall functions and identifies component functions. Also, the interfaces between functional components are identified. Both functional and physical elements can be presented in a function-component diagram that will illustrate the relationship between them (Figure 3.6) (Kamrani, 2002).

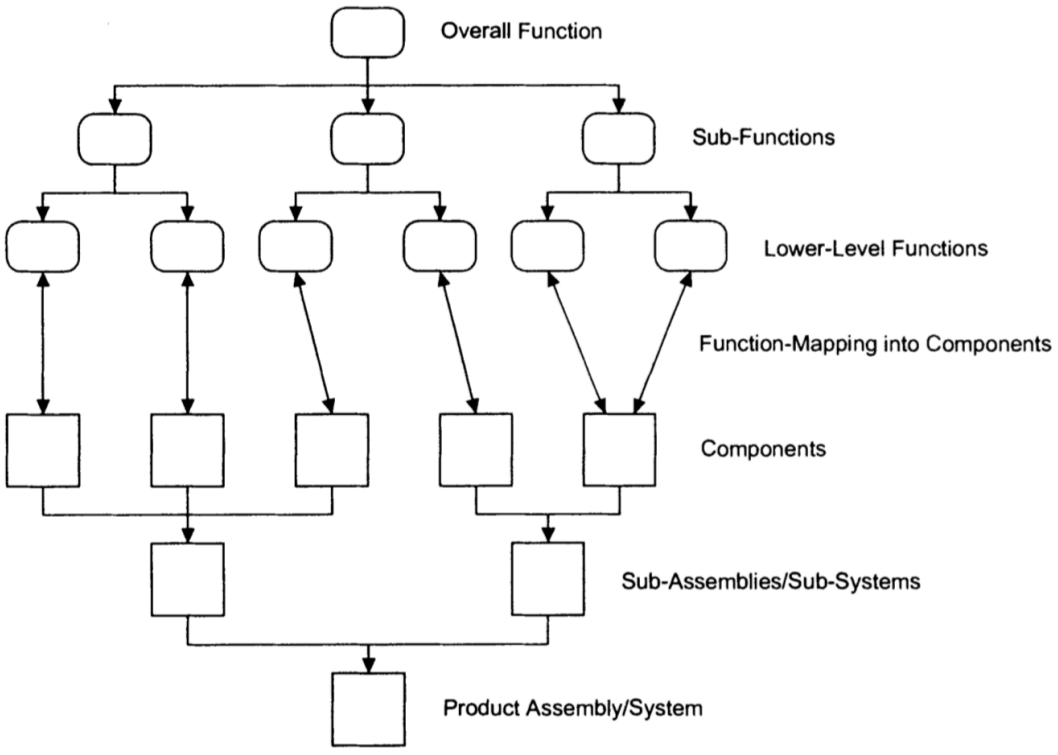


FIgure.2.6. 4 Function- structure diagram

Chapter 3 Guideline

3.1 Guideline of applying abstract art to furniture design to furniture design for mass customization

3.1.1 Overall method

The overall method generally has the following four steps

1. Break down the abstract art into visual elements
2. Break down the furniture into separate elements.
3. Interpret the visual elements of each furniture functional elements
4. Design the overall product system for mass customizarion

The whole design process is based on three parts: furniture, art and mass customization (Figure3.1).

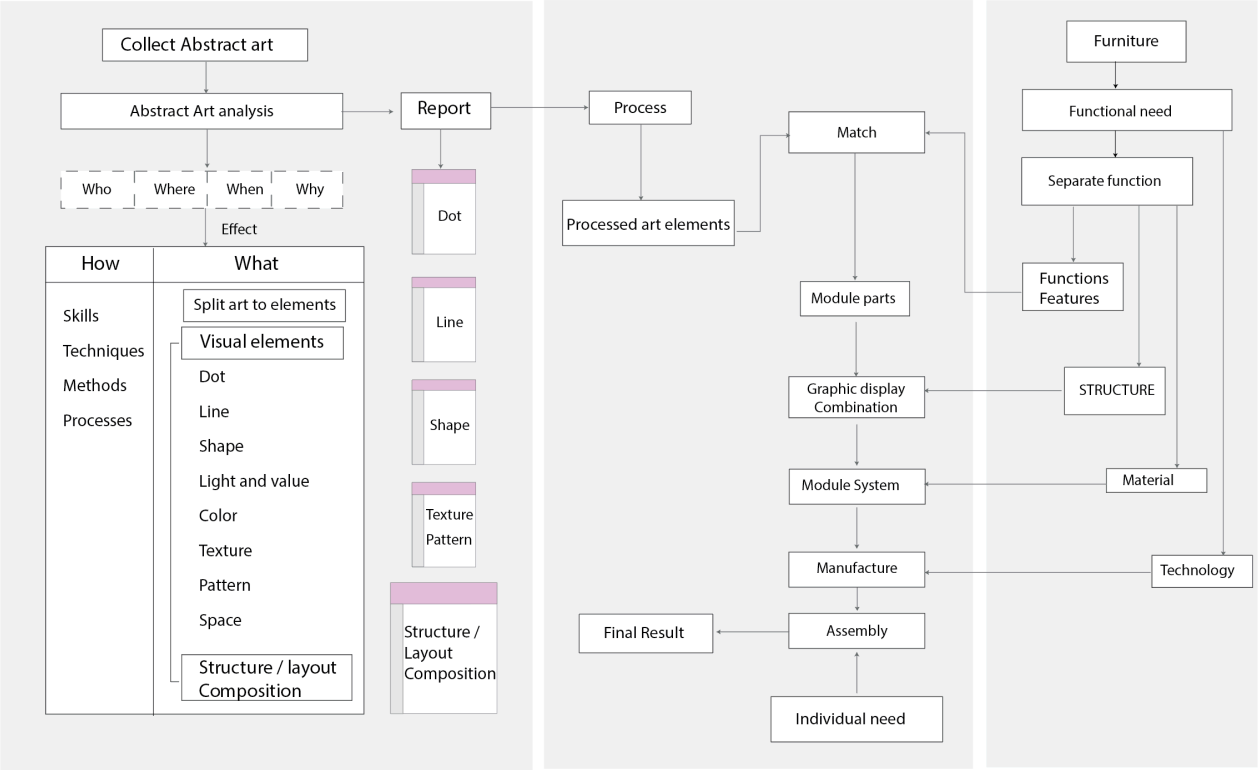


Figure 3. 1

The furniture part requires the designer to have the knowledge base for making design decisions. And the art part mainly is to analyze abstract art and process visual elements. Last is to bring furniture's' function and abstract art's visual elements together for mass customization. The main solution to mass customization is modular design and designing a product family for consumers to choose their preferences regarding shape, color, and construction ways etc.

3.1.2 Art analysis and break down to elements

Starting with abstract art, whether it is a style or specific artist's arts, we can use 5H1W to analyze them. "When", "Where" and "Who" are optional analysis parts which can give the designer a broader background to understand the original ideas of artists， while it is not necessary to only see it in the perspective of the author. So, the focus will be the "what" and "how" so that designers can directly absorb the essence of abstract art to service the design.

5W1H to analysis art

Who	When	Where	What	How	Why
Artists	Date Historical	Provenance Location	Visual elements Line Shape Light and value Color Texture Pattern Space Structure / layout Composition	Skills Techniques Methods Processes	Overall mood Subject matter Themes Issues Narratives Stories Ideas Instinctual response Symbolic value

Table3. 1

3.1.2.1 Optional analysis

The reason why this is optional is that this process is trying to find the artist' s point of view why he or she creates the work. While as designer, we can have our own understanding of what we see directly.

The following tables are reference materials. Designer can start with them to find artist messages to fill Table 3.2. Not all the entries are available or important for the arts creation. Even though we find all the information we need, we need to do one more step that only leaves the parts which are affected the artist's work most. For example, by reading from the article, if the artist we study is heavily influenced by feminism, his or her beliefs is irrelevant, than there is no need to show that information in the report (Table 3.3)

Who	Artists Biographical details	Personal situation	
		Family and relationships	
		Psychological state	
		Gender	
		Education	
		Religion	
		Interests	
		Values	
		Beliefs	
When	Date	Historical events	
		Natural events	
		Social movements , Political events	
Where	Provenance Location	Local traditions , customs	
		Climate	
		Economic situation	

Table 3. 2

Who	Biographical details Artists	Personal situation		Effect → Why
		Family and relationships		
		Psychological state		Overall mood
		Gender		Subject matter
		Education		Themes
When	Date	Social movements		Issues
Where	Provenance Location	Local traditions , customs		
		Economic situation		

Table3. 3 Example Output of "who, when, where, why" questions

3.1.2.2 Key sections to analyze abstract art

How

How					
		✓			✓
Skills Techniques	Glazing		Methods Processes	Idealized	
	Stippling			Indistinct	
	Impasto			Hidden	
	Scumbling			Distorted	
	Knocking down			Exaggerated	
	Dragging			Stylized	
	Dry brush			Reflected	
	Flooding			Reduced to simplified/Minimalist form	
	Other : _____			Primitive	
				Abstracted	
				Concealed	
				Suggested	
				Blurred or focused	
				Other : _____	
Description :			Description :		

Table3. 4

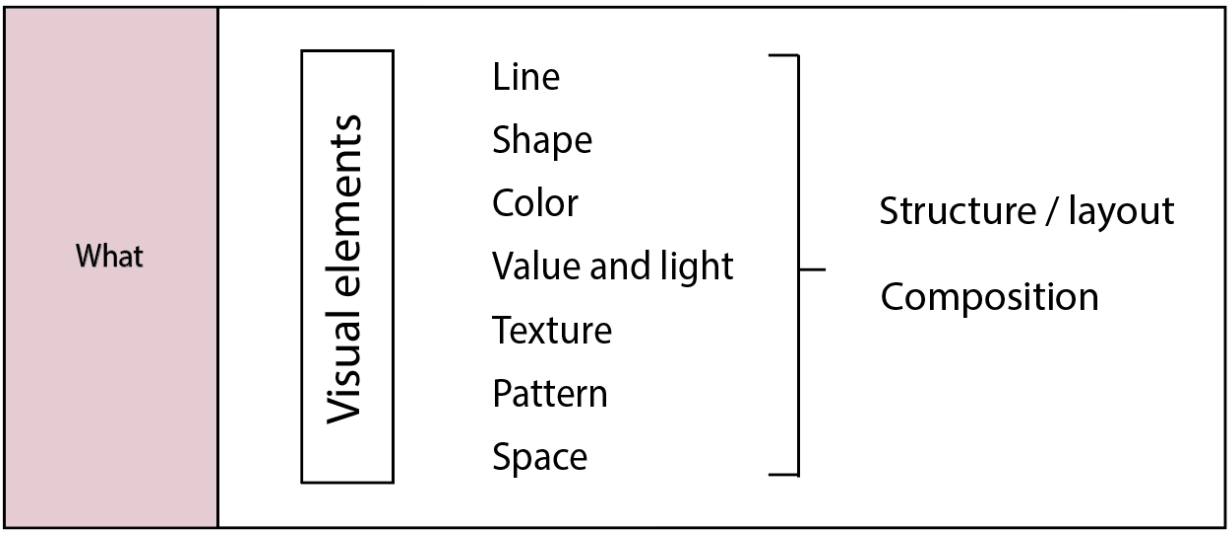
Cheklist of “how” analysis

How			
Skills Techniques	Dry brush	Methods Processes	Distorted
Description : Only a very small amount of paint is taken up. The end of the brush is then dragged along the surface so that the paint is only picked up by its texture, creating a semitransparent layer.		Description : Spatial distortion Perspectival space can be distorted or skewed by adjusting the geometry. the art create surprising and alarming shifts in space.	

Table 3. 5

Example of outcome of “how” analysis

What



The following Table3.6, Table3.7, Table3.8, Table3.9, Table3.10, Table3.11, and Table3.12, give the designer reference tables to rationally analyze all the visual elements. The tables only provide a clue for designers to start with. Similarly, not all the elements are included in the one style of art or one artist's works, thus not all the analysis is necessary for one genre or one artist. All the qualities of line, shape, color, value, texture, pattern, and space can be defined by with relatively rational values like specific how long is the line, what RGB values of the color. Also, they can be described by adjectives which have space for designer to adjust the quality of the design. For example, if the art has a lot of long lines, we can mature how long it is or generally give a verbal description – long line as reminder for later design. Obviously, the numerical definition will be more accurate for later design to keep the original feeling of the abstract art but it is less adjustable. The verbal description has too much uncertainty. The best way is use this two methods work at the same time, then the verbal description can be limited by quantitative definition then， every designers in the team can have the consensus what "long" means. The tables give a convenient way for designers to understand art by only choosing adjectives, and, if some descriptions are not included, the designer can add his or her own words

and delete the unrelated words. After analysis, in the end of the table is the space for illustrate the art elements which may be useful for later design.

Line

Line				
Quality	Depth: Thick- thin			
	Weight: Light -heavy			
	Direction: Tendency			
	Angles: Vertical -horizontal 、degree			
	Length: Short- Long			
	Number: Many -few			
Types of Line		✓	Function	Define form and edges
	Soft			Describe form
	Bold			Dvide, segment, or separate different areas
	Delicate			Express movement&energy
	Feathery			Evoke ideas ,moods , emotions ,and atmosphere
	Indistinct			Create a sense of depth or movement through space
	Faint			Create a sense of stability and permanence
	Intermittent			Could suggest height, reaching upwards or falling
	Irregular			Create contrast or emphasis, balance the composition
	Freehand			Suggest rigidity, strength
	Expressive			Suggest tension or unease
	Ruled			Suggest a sense of agitation or panic
	Mechanical			Suggest nature, peace, movement or energy
	Loose			Simulate material qualities, textures, patterns or rhythm
	Blurred			Manipulate the viewer's gaze,
	Dashing			directing vision or lead the eye to focal points
	Meandering			Other
	Gestural, fluid			
	Flowing			
	Jagged			
	Spiky			
	Sharp			
	Other			
Dominating Lines	Boundary lines			
	Outlines			
	Construction lines			
	Parallel lines			
	Horizontal lines			
	Vertical lines			
	Abstract lines			
	Perpendicular lines			
	Angular lines			
	Chaotic lines			
	Curving lines			
	Repeating lines			
	Leading line			
	Other			
Illustrate the line from the art				

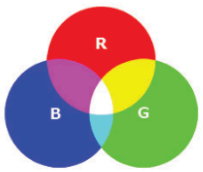
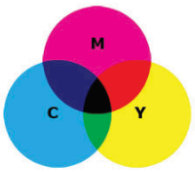
Table 3. 6

Shape

Shape				
Quality	Organic / geometric			
	Direction			
	Scale			
	Positive and negative shape			
Visual Language		✓	Relationship	✓
	Geometric			Grouped
	Angular			Overlapping
	Rectilinear			Repeated
	Curvilinear			Echoed
	Organic			Fused edges
	Natural			Touching at tangents
	Fragmented			Contrasts in scale or size
	Distorted			Distracting
	Free-flowing			Awkward junctions
	Varied			Other: _____
	Irregular			
	Complex			
	Minimal			
	Other: _____			
Edges Of form	Fade away		Present Ways	Idealized
	Blur			Indistinct
	Ripped or torn			Hidden
	Distinct and hard-edged			Distorted
	Other: _____			Exaggerated
				Stylized
Variety or Repetition				Reflected
	Repetition may reinforce ideas			Reduced to simplified
	Balance composition /			Minimalist form
	Create harmony / visual unity			Primitive
	Variety overwhelms the viewer			Abstracted
	Other: _____			Concealed
				Suggested
				Blurred
				Focused
				Other: _____
Illustrate the shape from the art				

Table 3. 7

Color

Color					
Quality	Lightness	Light or dark	 RGB - Subtractive Colors	 CMYK - Additive Colors	
	Chroma	The amount of color degree of saturation			
	Hue	Color name: Red, Yellow, Green, Blue, Purple; Yellow-Red, Green-Yellow, Blue-Green, Purple-Blue, Red-Purple			

Color scheme	✓	Number of Colors	✓
	Harmonious		Broad or limited color palette
	Complementary		Variety or Unity
	Primary		Other: _____
	Monochrome	Color Contrast	Extreme contrasts
	Earthy		juxtaposition of complementary colors
	Warm		Garish / clashing / jarring
	Cool/cold		Other: _____
	Other: _____		
Intensity of the colors	Vibrant	Function	Expressing symbolic or thematic ideas
	Bright		Descriptive or realistic depiction of local color
	Vivid		Emphasizing focal areas
	Glowing		Relationships with colors in surrounding
	Pure		environment
	Saturated		Creating balance
	Strong		Creating rhythm/pattern/repetition
	Dull		Unity and variety within the artwork
	Muted		Lack of color places emphasis upon shape, detail and form
	Pale		Other: _____
	Subdued		
	Bleached		
	Diluted		
	Other: _____		

Illustrate the color from the art

Table 3. 8

Value/tone/light

Value /tone/light			
the tone of object itself+ linght=Value			
Quality	Degree of tone	Darks Mid-tiones Highlights	
	Tonal range	Broad Limited	
	Type of light	Sunshine Light bulbs Torches Lamps Luminous surfaces Other:	
	Number of Light sources	Single consistent Multiple	
The effect of light			✓
	Mimics natural lighting conditions at a certain time of day or night		
	Figures lit from the side to clarify form		
	Contrasting background or spot-lighting used to accentuate a focal area		
	Soft and diffused lighting used to mute contrasts and minimize harsh shadows		
	Dappled lighting to signal sunshine broken by surrounding leaves		
	Chiaroscuro used to exaggerate theatrical drama and impact		
	Areas cloaked in darkness to minimize visual complexity		
	Enhance our understanding of narrative, mood or meaning		
	Other: _____		
The effect of shadows	Anchors objects to the page		
	Creates the illusion of depth and space		
	Creates dramatic contrasts		
	Other: _____		

Table 3. 9

Texture/pattern

Texture Pattern							
Type of texture			Character of texture		✓		✓
				Smooth		Shiny	
				Varnished		Glassy	
				Glossy		Polished	
				Matte		Silky	
	✓			Grooved		Indented	
	Texture illusion			Stressed			
	Fact texture			Bumpy		Scratched	
	Area texture			Rough		Sandy	
	Other:			Grainy		Gritted	
				Leathery		Spiky	
				Other:			
Texture create						✓	
	Impasto mediums						
	Sculptural materials						
	Illusions or implied texture, such as cross-hatching						
	Finely detailed and intricate areas						
	Organic patterns such as foliage or small stones						
	Repeating patterns						
	Ornamentation						
	Other:						
Function of texture	Be used intermittently to provide variety;						
	Repeating pattern creates rhythm;						
	Patterns broken create focal points;						
	Textured areas create visual links and unity between separate areas of the artwork;						
	Balance between detailed/textured areas and simpler areas						
	Glossy surface creates a sense of luxury;						
	Imitation of texture conveys information about a subject, i.e. softness of fur or strands of hair.						
	Other:						
Illustrate the texture/pattern from the art							

Table 3. 10

Space

Space		
Spatial depth	Shallow —— Deep	
Density	Mass —— Void	
Ways to create Spatial impression		✓
	Layering of foreground, middle-ground, background	
	Overlapping of objects;	
	Use of shadows to anchor objects;	
	Positioning of items in relationship to the horizon line;	
	Linear perspective – learn more about one point perspective here;	
	Tonal modeling;	
	Relationships with adjacent objects and those in close proximity –	
	Including the human form – to create a sense of scale;	
	Spatial distortions or optical illusions;	
	Manipulating scale of objects to create 'surrealist' spaces where true scale is unknown	
	Gradiens in size , value , or clarity	
	Diagonal directions	
	Other: _____	

Vew point	✓	Effect of view point	✓
Worm's view		Allows certain parts of the scene to be dominant and overpowering or squashed	
Aerial view			
Looking out a window or through a doorway		Condensed and foreshortened	
A scene reflected in a mirror or shiny surface		Suggests a narrative between two separate spaces	
Looking through leaves			
Multiple viewpoints combined		Provides more information about a space than would normally be seen	
Linear perspective			
Isometric perspective			
Other: _____		Other: _____	

Table3. 11

Composition/structure/layout

Composition /Structure / layout			
Mathematical proportion		Less predictable Arrangement	
	✓		
Rule of thirds			
Golden ratio or spiral			
Grid format			
Geometric			
Dominant triangle			✓
Circular composition		Chaotic	
Central location		Random	
Two centers		Accidental	
The bridge		Fragmented	
Cantilever(Suspended in the air		Meandering	
The even spread		Scattered	
The radial burst		Irregular or spontaneous	
Emphasis on diagonality		Other:	
Emphasis on horizontality			
Emphasis on verticality			
Other:			
Alignment and positioning of parts		The effect of positioning	
Edges aligned			
Items spaced equally			
Simple or complex arrangement		Imply hierarchy	
Overlapping, clustered or concentrated objects		Help understand relationships between parts	
Dispersed, separate items			
Repetition of forms		Create rhythm	
Items extending beyond the frame		Other:	
Frames within frames			
Bordered perimeter or patterned edging			
Broken borders			
Other:			
Fifteen general modes of presentation		Principle of composition	
1. Deep space			
2. Shallow space		Unity and Variety	
3. Density (busy picture- filling)		Balance (symmetry, asymmetry)	
4. Sparsity (simplicity)		Emphasis and Subordination	
5. Dense and sparse (a complex and an "empty")		Scale and Proportion (weight, how objects or figures relate to each other)	
6. Two-dimensionality			
7. Volume and space dominant		Mass/Volume (three-dimensional art)	
8. Straight edge dominant		Rhythm	
9. Straight versus curve		Simplicity	
10. Linear, closed shapes		Hierarchy	
11. painterly, open shapes			
12. Line dominant			
13. Value dominant			
14. Texture dominant			
15. Color dominant			

Table 3. 12

3.1.1 Process the report to processed visual elements

The outputs of previous steps are the reports about the visual elements of abstract art. According the reports and definition, the next step is to extract visual elements from paintings, as shown in the flowchart, according to the line report, shape report, texture/pattern report to get L_1, L_2, L_3……Ln, S_1, S_2, S_3……Sn, T_1, T_2, T_3……Tn, P_1, P_2, P_3……P_n. In order to express compactly we use $V_{1\text{-}n}$ to represent extracted visual elements.

The next step is to process the $V_{1\text{-}n}$ to better serve the furniture design. The process can consult the composition and strucure reports to reconstruct the art elements. And according to gestalt psychologists the change is limited to a certain range which will not affect the impression of the art.

Generally there are five ways to process $V_{1\text{-}n,}$ including deconstruction, integration, additon,subtraction, and transformation (Figure3.2).

Deconstruction is to break the original elements into new entireties by means of decomposition cutting, recombining, etc. Also deconstruction could be replaced by the related parts of other elements. The distinctive parts need to be preserved.

Refactoring can be divided into the integration of the same elements or different elements. The integration of the same elements is to deconstruct the original graphics according to certain rules to form a new design. Combining the art author's intent with the potential relevance of the graph makes the graph have both new and original character. The integration between different elements is to exchange part of something with the same position of another object.

Addition is a method of combination of two or more graphics through a certain method to form a new visual elements. The graphical elements that can be added together tend to have a

certain degree of similarity. The way of addition includes juxtaposition, repalecement, palcement, duplication etc.

Subtraction mehod is also a very important process, for example, cutting ,boolean, splitting, separation,etc. Cutting is to cut and decompose a single elements, and the angle and area of cutting can make the graphic different. Boolean is scoop or cut from the original shape. Due to the shape, size, density ,etc. of the cutting surface used in the excavation, the results can produce different versions. Splitting and separating can have great effects, and can change the basic shape from square to round, from large to small, from curved to straight, etc.

We use different combinations of addition and subtraction to integrate different materials to form new shapes. In this process, in order to make the new image complete and identical, the processing looks for similar features in the material, and transform the element to adapt to each other. Commonly used deformation processing methods include stretching, scaling and twisting. Twisting exerts different degrees of force on the part of the basic form.

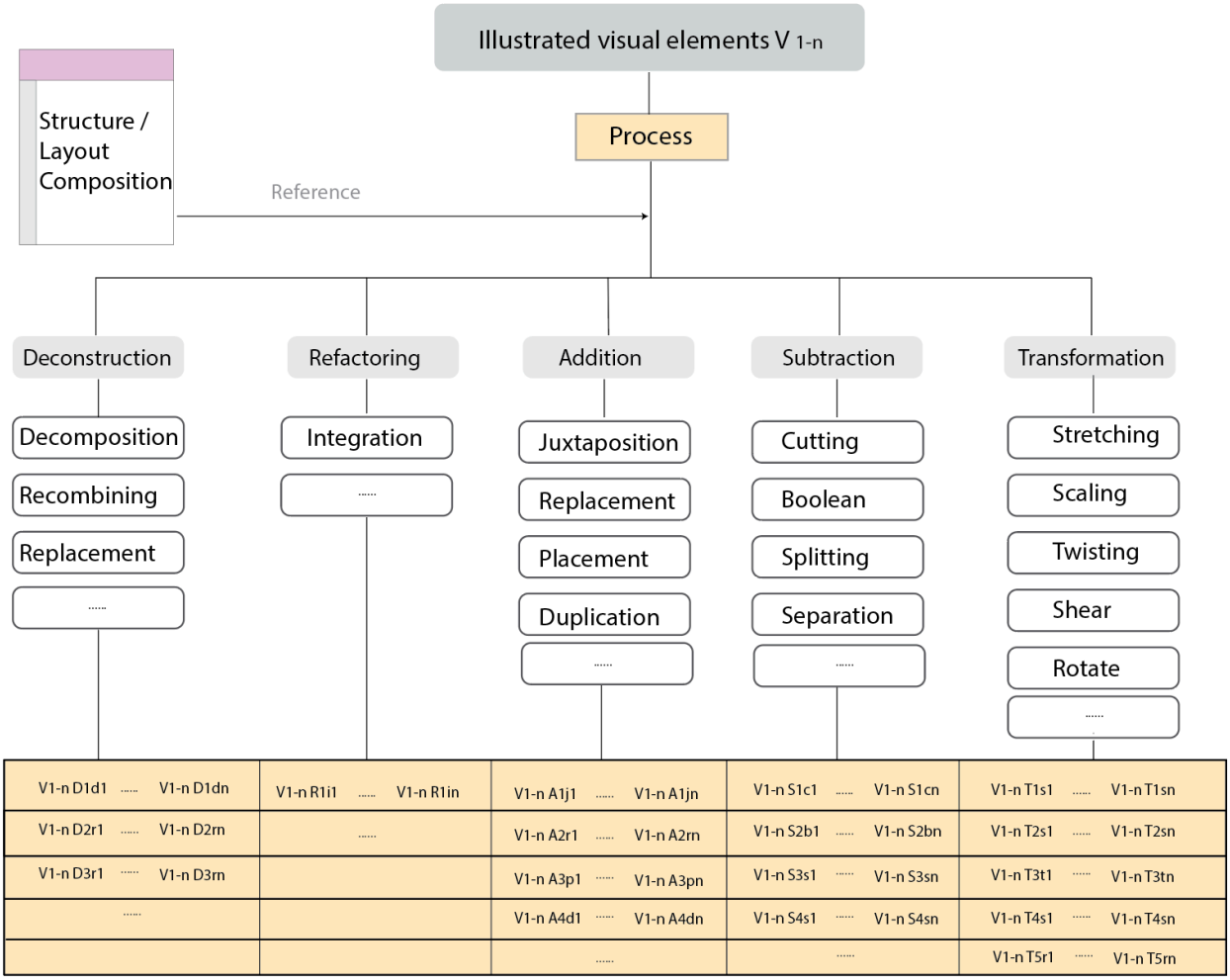


Figure 3. 2

3.1.2 Interpret the visual elements of each furniture elements

The next step is to combine furniture and processed abstract art elements together. If it is simple functional furniture like a table, a chair, and a case, etc., the designer may then go through A process (Fig3.3) The designers need to decide the type of furniture they going to design, then break down to essential features A1, A2, A3…$A_{n.}$ If necessary, the designer can keep breaking the features of furniture down to $A1_1$, $A1_2$… $A1_{m.}$ Once we have separate elements of furniture $A1_1$, $A1_2$, $A2_1$…etc., then is time to let the art elements interact with them to find appropriate combinations.

Funiture feasures base interaction

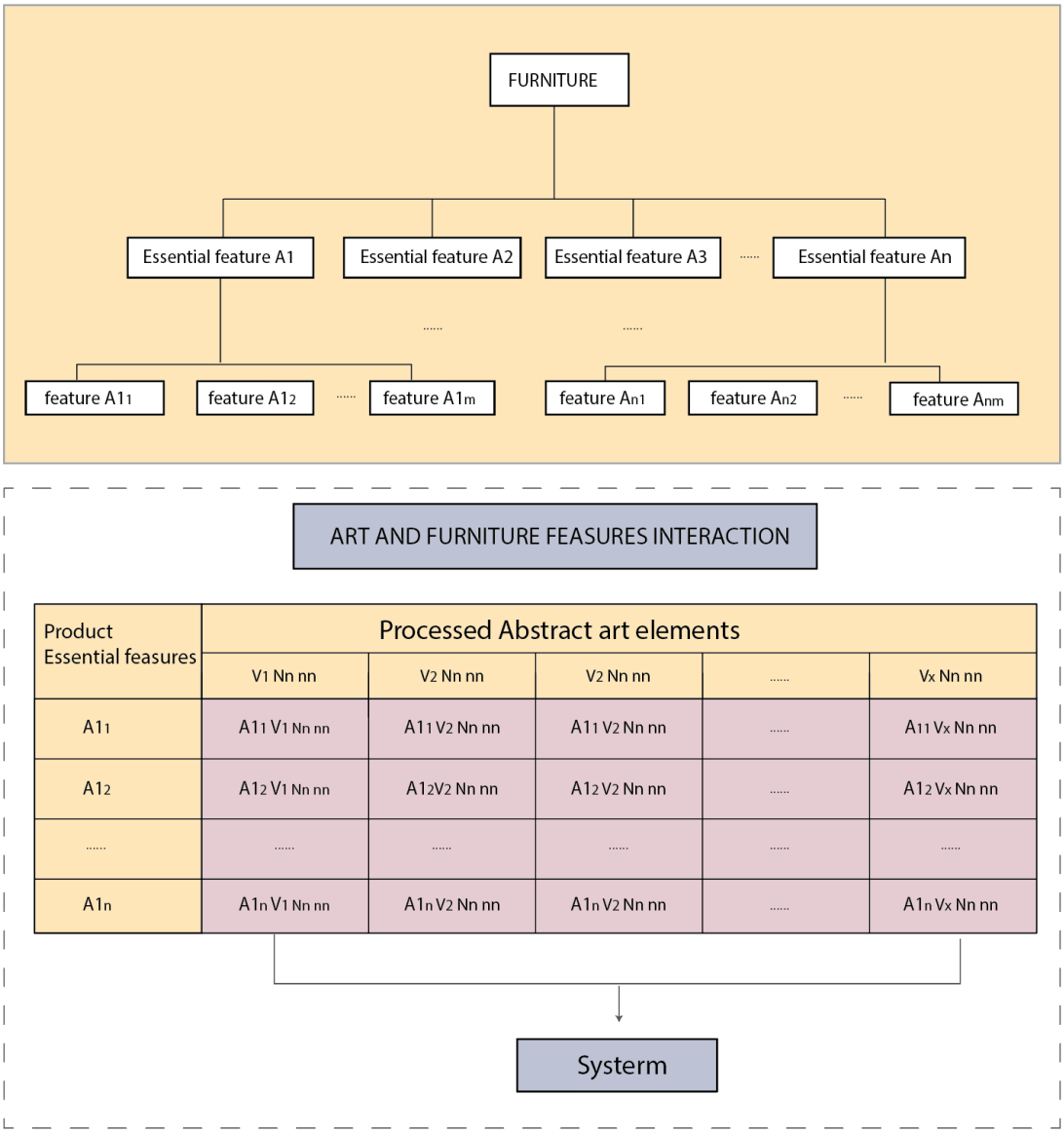


Figure 3. 3

3.1.3 Concept to final design

After we have the results from previous steps, we already have concepts. The further step will be considering the modularity and assembly to final design(Fig3.4).

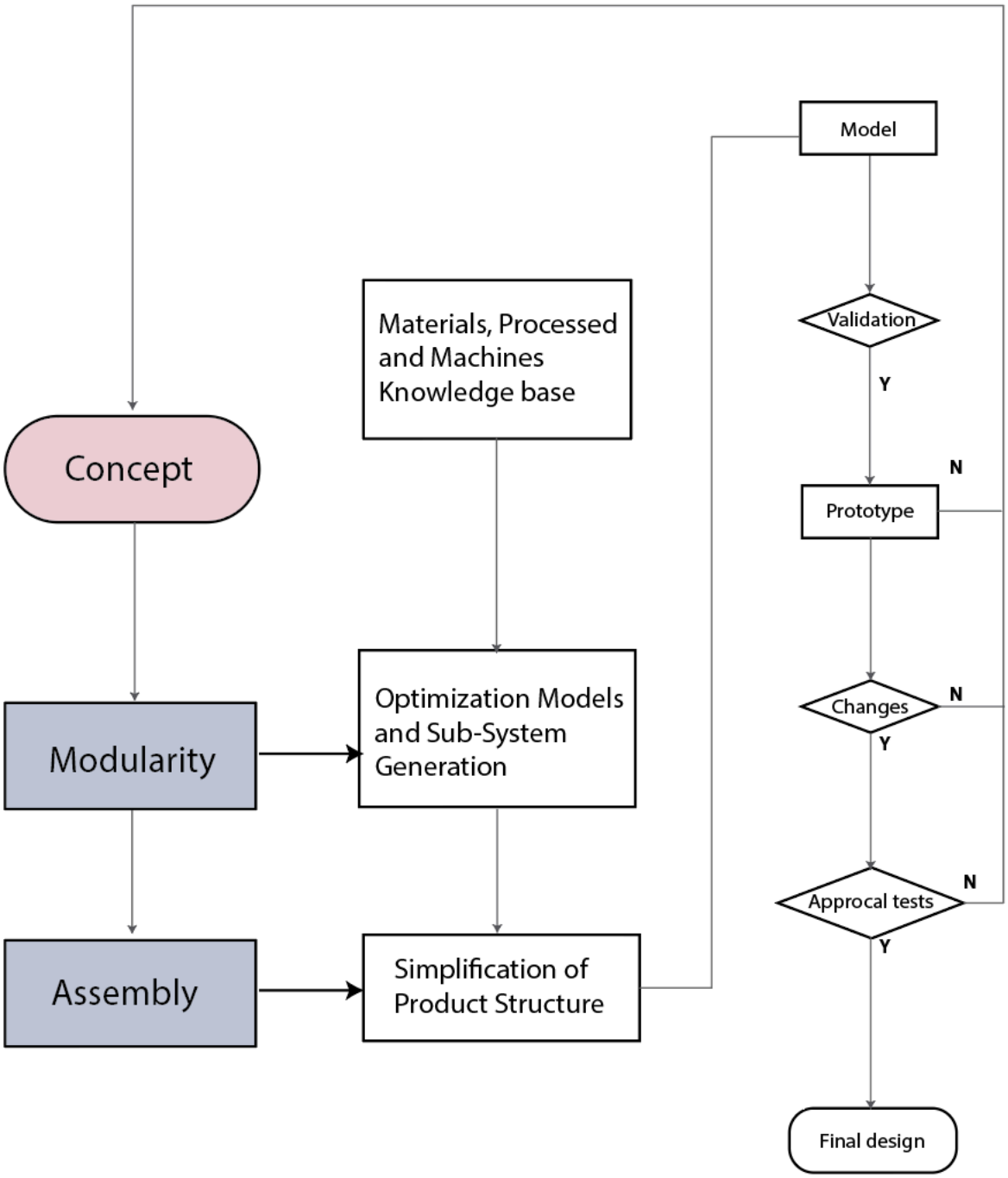


Figure 3. 4

3.1.4 Modularity

Particularly when designers are considering modularity for furniture design, there are three main parts which are common modules, connection types, and unique modules (Fig3.7).

Some connection types can be found in Chapter 2.2.6: furniture joints, which gives designer some choices, or designers can have their own connection type. Common modules must be standardized and can be used repeatedly. In art furniture some designs may have unique modules which cannot be shared in product system.

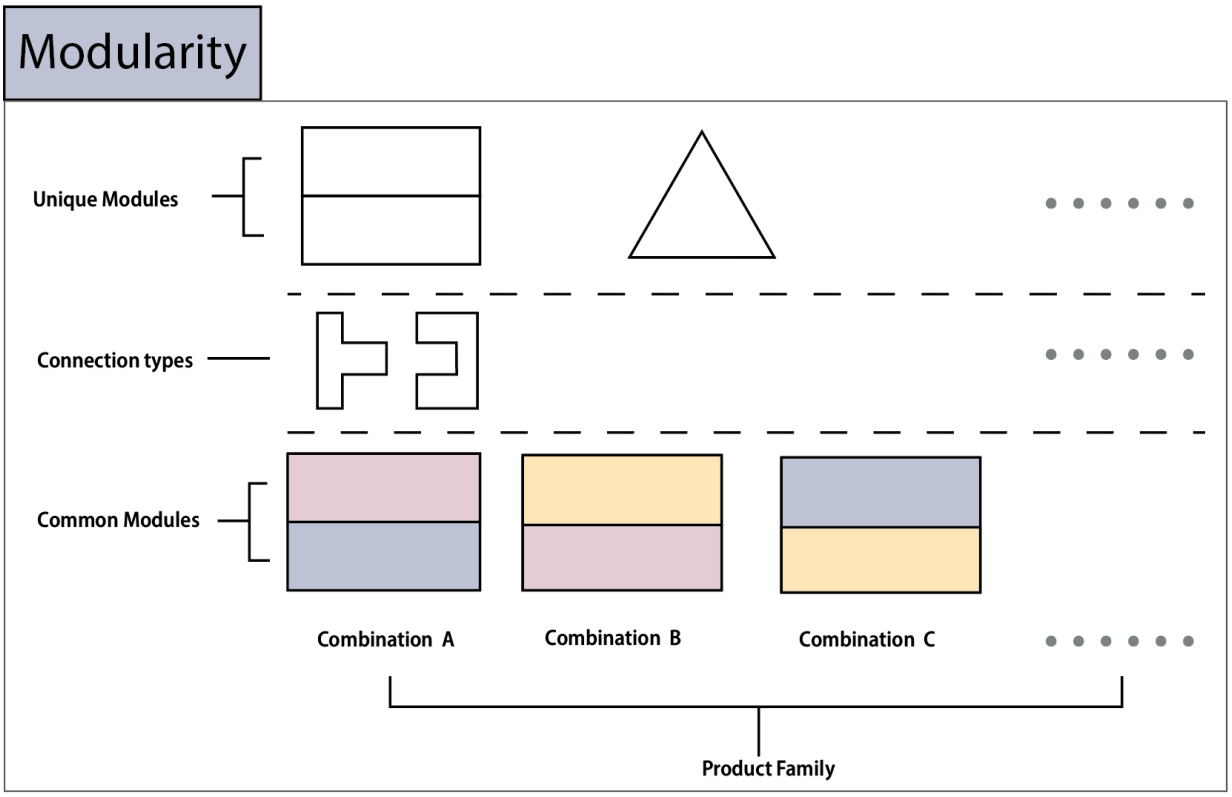


Figure 3. 5

Chapter 4 Application

4.1 Application of the method

4.1.1 Art collection

The art I choose to apply to the furniture design was pained by Luc Peire (1916-1994). The reasons I choose this artist is that the artist evolved from expressionism, ending up with constructivism, even interacting with interior and architectural design at the same time. And his paintings are plentiful for designers to absorb inspirations. Generally, his style is reduced and stylized human figures to present human beings as spiritual beings, symbolized in vertical movement and situated in a balanced space. The original art works are shown in Figure 4.1.

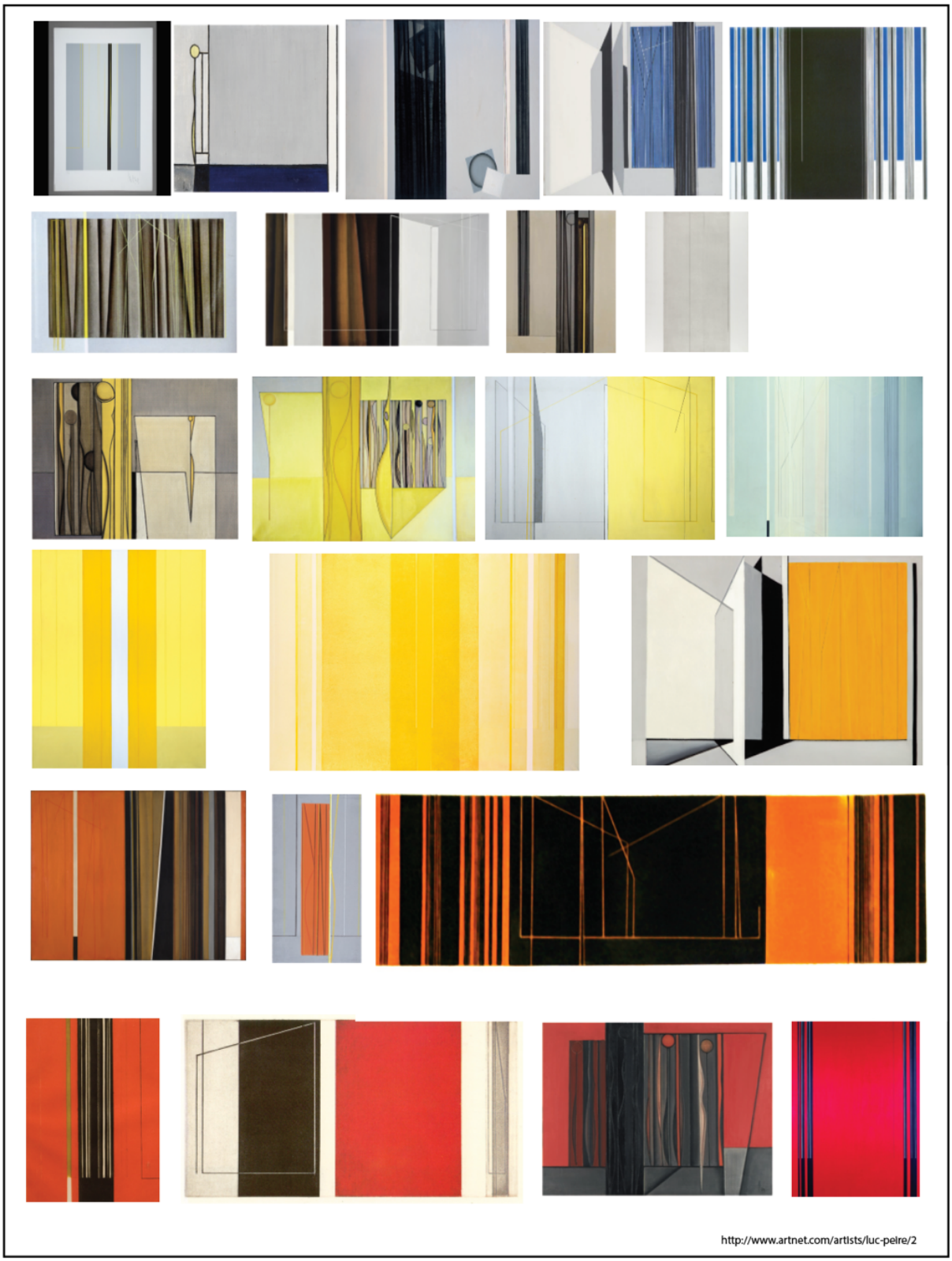


Figure.4. 1

4.1.1.1 Optional analysis

His works mainly belong to constructivism although he was influenced by expressionism in his early age. By 1955, after the two years that he traveled the Congo, his work had become predominantly abstract. The most influential background of the artist is the journey in the Congo. “The proud, statuesque figures of Congolese women became Peire’s primary theme and the formal point of departure for a consistent stylistic and compositional development that was to culminate in an entirely non- objective conception of art” (Vermeulen, 2012).

<table>
<tr><td rowspan="2">Who</td><td rowspan="2">Artists</td><td>Luc Peire (1916-1994)</td><td rowspan="2">  </td></tr>
<tr><td>Experience</td></tr>
<tr><td rowspan="2">Where</td><td rowspan="2">Provenance
Location</td><td rowspan="2">In the painter’s studio in Knokke Belgium</td><td rowspan="2">In 1951 journey in the Congo
 
</td></tr>
<tr><td>When</td><td>Date</td><td>After 1955</td></tr>
</table>

Table4. 1

4.1.1.2 The artist development process

Figurative painting

In the beginning, the paintings still felt very close to reality, and his first concern was to seize the specific character of his motifs and render them in a moving way. It was an expressionist type of preoccupation (Figure 4.1).

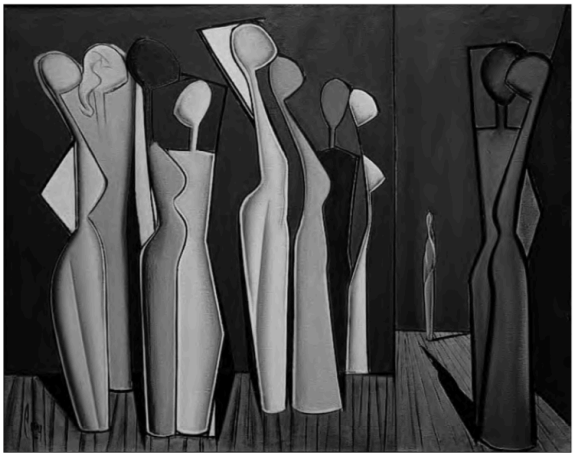


Figure4. 1

Luc Peire, Familie Denghese [Denghese family] (1953). Oil on canvas, 100 x 130 cm. Signed bottom left. Collection and photograph Studio Luc Peire – Foundation Jenny & Luc Peire, Knokke.

Through the 1950s these stylized figures became straight lines, a representation of humanity in an idealized space that might be a room, an artist's studio or a stage. Although it is entirely conveyed in a single geometric figure，the tall woman's silhouette preserves its full power of concrete evocation. The pattern of lines and colors has been minutely decanted, but it nevertheless remains complex, which amounts to saying that the work in question is not entirely detached from reality (Figure4.2).

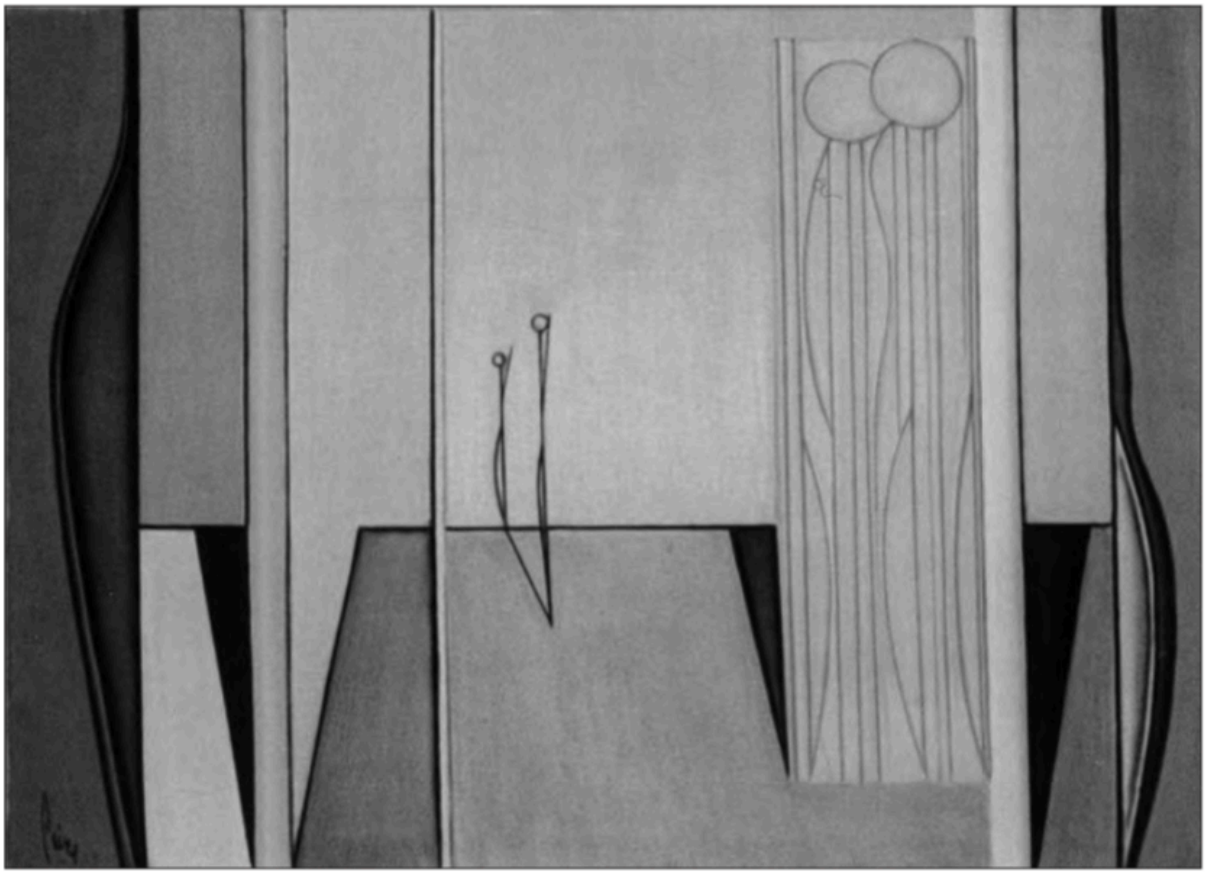


Figure4. 2

Luc Peire, Jaune dans l'espace [Yellow in space] (1955). Oil on canvas, 81 x 100 cm. Signed a nd dated bottom left. Collection and photograph Studio Luc Peire – Foundation Jenny & Luc Peire, Knokke.

In the end, the Wattutsi woman or the mainikin were to become nothing more than a vertical line, topped by a circle, or a small balloon attached to a string, and delicate colored. When the geometric motif in turn disappeared, the canvas no longer offered anything but tall elongated surfaces, completed by an ingenious pattern of vertical lines and planes, by a horizon and by a few obliques at times suggesting a depth or, in any case, an idea of a break in the harmonious whole evoked by the ascending elements. What remained, above all, was color, which was now given full play (Figure 4.3).

Figure4. 3

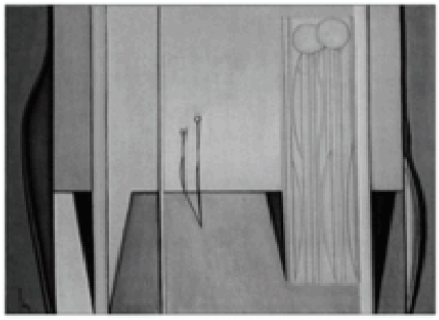
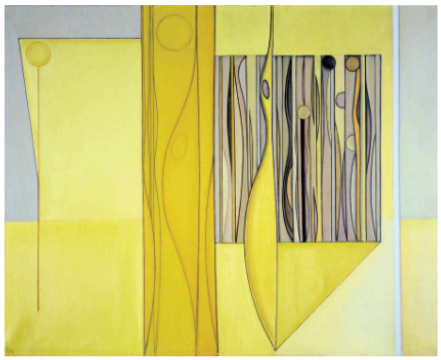
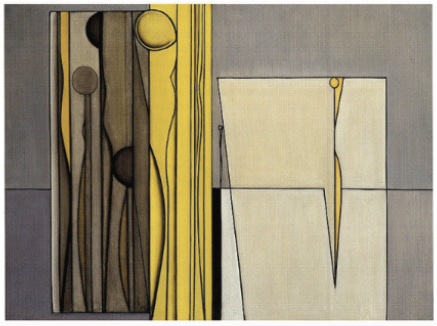
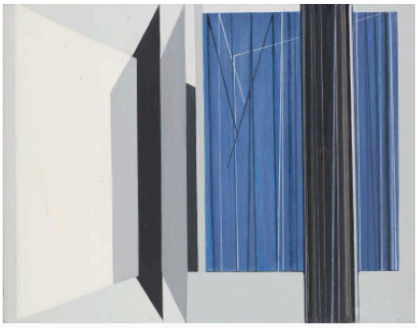
Semi-abstract		
Abstract	Objective	Non-objective
		
		
		

Table4. 2

4.1.1.3 Visual elements analysis output

In Luc's art the most distinctive elements are line shape and color; thus, the analysis will mainly focus on these three elements.

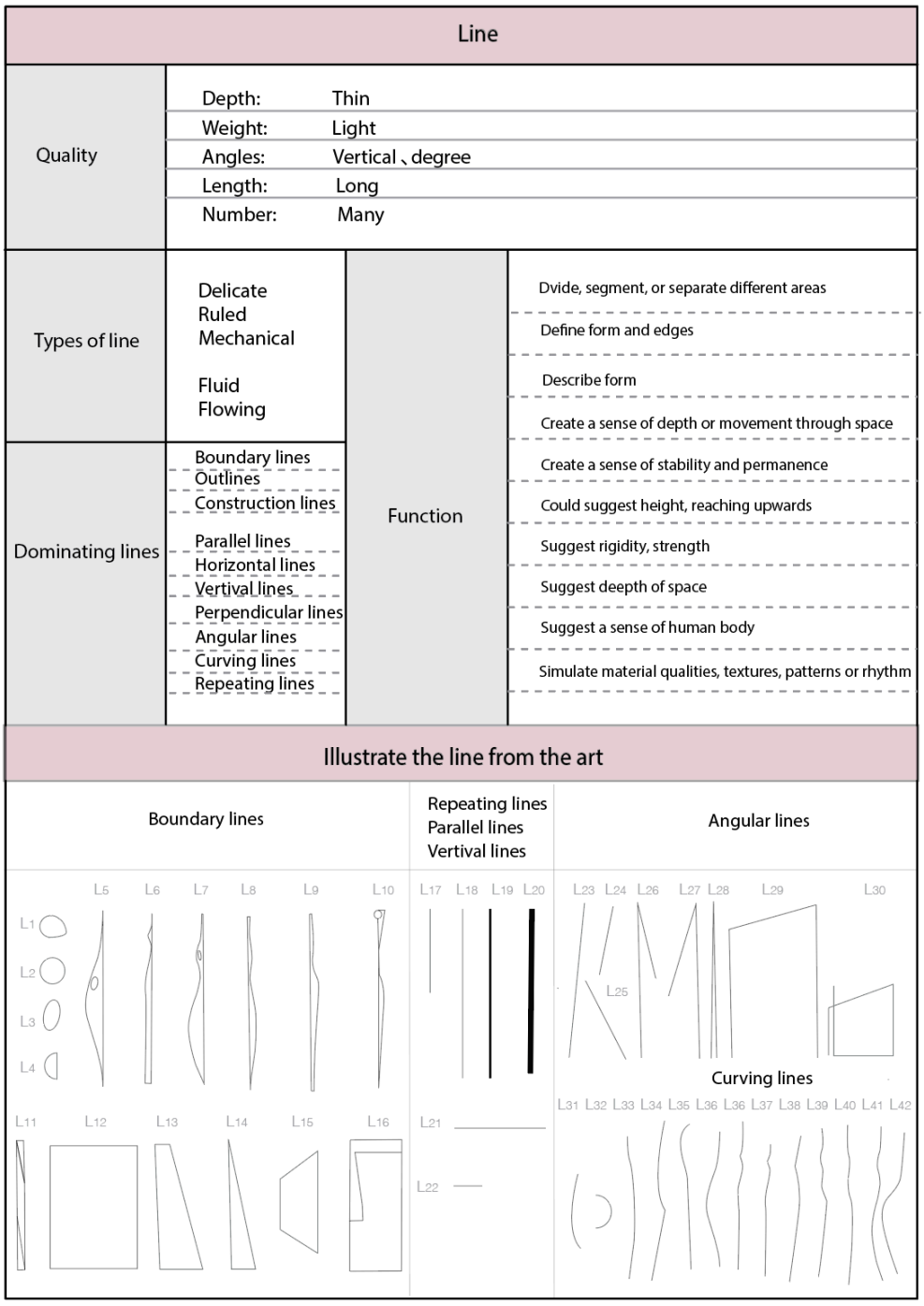


Table4. 3

Shape			
Quality	Most geomatric /decotive Organic Vertical Scale	Relationship	Grouped Overlapping Repeated Echoed Contrasts in scale or size
Visual language	Geometric Angular Rectilinear		
Edges of form	Hard-edged	Present Ways	Stylized Reflected Reduced to simplified Primitive Abstracted
Repetition	Repet Vertical shapes reinforce ideas Balance composition and/ Create harmony / visual unity		

Shape

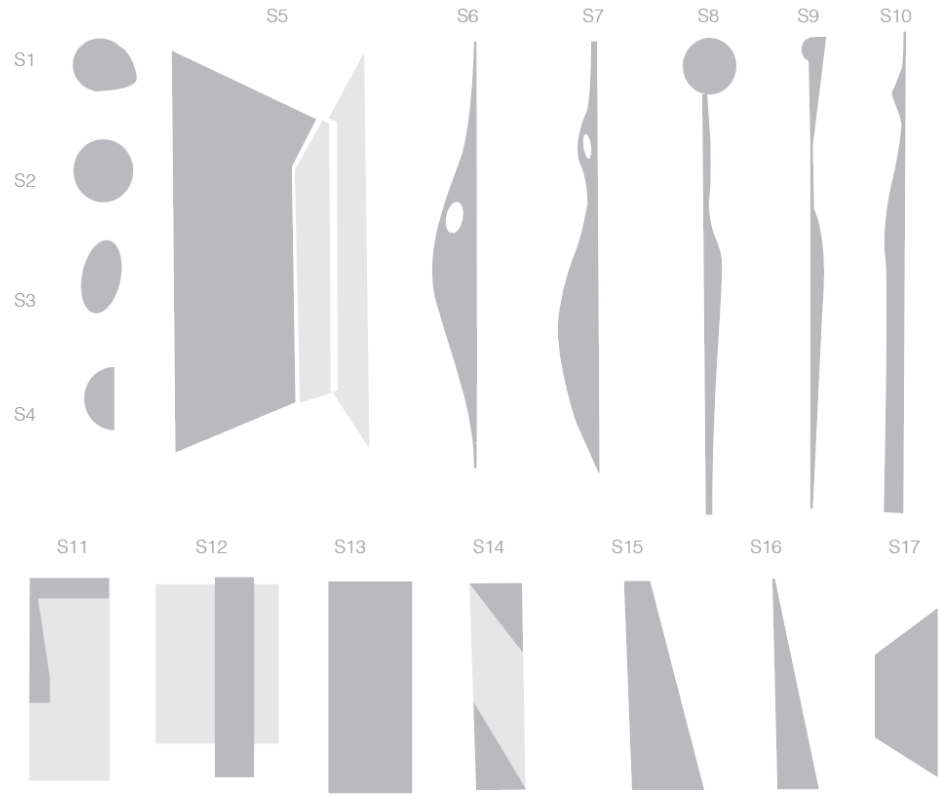


Table4. 4

<table>
<tr><th colspan="2">Composition /Structure / layout</th></tr>
<tr><td colspan="2">Mathematical proportion</td></tr>
<tr><td colspan="2">Rule of thirds
Geometric
Central location
Two centers
Emphasis on verticality</td></tr>
<tr><td>Alignment and positioning of parts</td><td>The effect of positioning</td></tr>
<tr><td>Edges aligned
Items spaced equally
Dense and loose arrangement
Overlapping, concentrated objects
Repetition of forms
Frames within frames</td><td>Imply hierarchy
Help understand relationships between parts
Create rhythm</td></tr>
<tr><td>Fifteen general modes of presentation</td><td>Principle of composition</td></tr>
<tr><td>Line dominant
Color dominant
Shallow space
Dense and sparse (a complex and an “empty”)
Two-dimensionality
Linear, closed shapes</td><td>• Unity and Variety
• Balance (symmetry, asymmetry)
• Emphasis and Subordination
• Scale and Proportion (weight, how objects or figures relate to each other)
• Rhythm
• Simplicity
• Hierarchy</td></tr>
</table>

Table4. 5

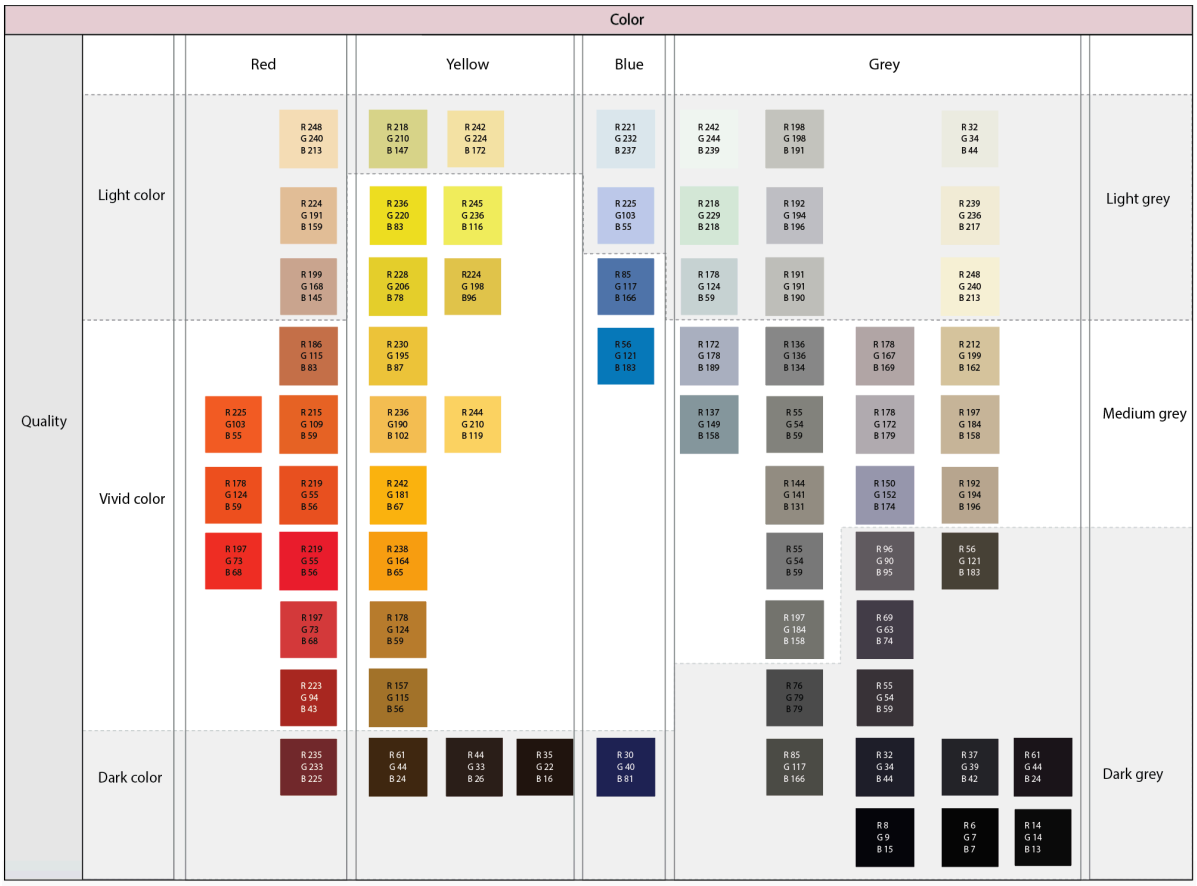

Color
Quality
Red
Yellow
Blue
Grey
Light color
Vivid color
Dark color
Light grey
Medium grey
Dark grey
R 248 G 240 B 213
R 218 G 210 B 147
R 242 G 224 B 172
R 221 G 232 B 237
R 242 G 244 B 239
R 198 G 198 B 191
R 32 G 34 B 44
R 224 G 191 B 159
R 236 G 220 B 83
R 245 G 236 B 116
R 225 G103 B 55
R 218 G 229 B 218
R 192 G 194 B 196
R 239 G 236 B 217
R 199 G 168 B 145
R 228 G 206 B 78
R224 G 198 B96
R 85 G 117 B 166
R 178 G 124 B 59
R 191 G 191 B 190
R 248 G 240 B 213
R 186 G 115 B 83
R 230 G 195 B 87
R 56 G 121 B 183
R 172 G 178 B 189
R 136 G 136 B 134
R 178 G 167 B 169
R 212 G 199 B 162
R 225 G103 B 55
R 215 G 109 B 59
R 236 G190 B 102
R 244 G 210 B 119
R 137 G 149 B 158
R 55 G 54 B 59
R 178 G 172 B 179
R 197 G 184 B 158
R 178 G 124 B 59
R 219 G 55 B 56
R 242 G 181 B 67
R 144 G 141 B 131
R 150 G 152 B 174
R 192 G 194 B 196
R 197 G 73 B 68
R 219 G 55 B 56
R 238 G 164 B 65
R 55 G 54 B 59
R 96 G 90 B 95
R 56 G 121 B 183
R 197 G 73 B 68
R 178 G 124 B 59
R 197 G 184 B 158
R 69 G 63 B 74
R 223 G 94 B 43
R 157 G 115 B 56
R 76 G 79 B 79
R 55 G 54 B 59
R 235 G 233 B 225
R 61 G 44 B 24
R 44 G 33 B 26
R 35 G 22 B 16
R 30 G 40 B 81
R 85 G 117 B 166
R 32 G 34 B 44
R 37 G 39 B 42
R 61 G 44 B 24
R 8 G 9 B 15
R 6 G 7 B 7
R 14 G 14 B 13

Table4. 6

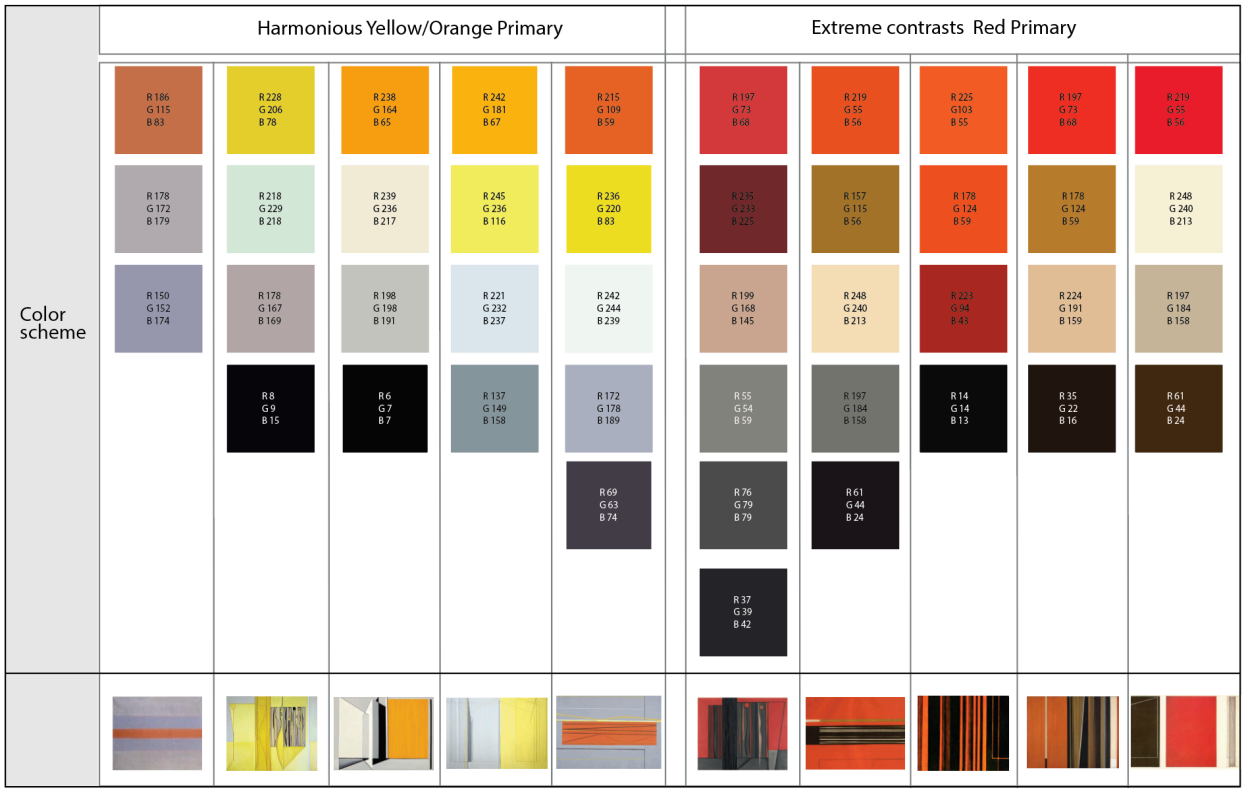


Table4. 7

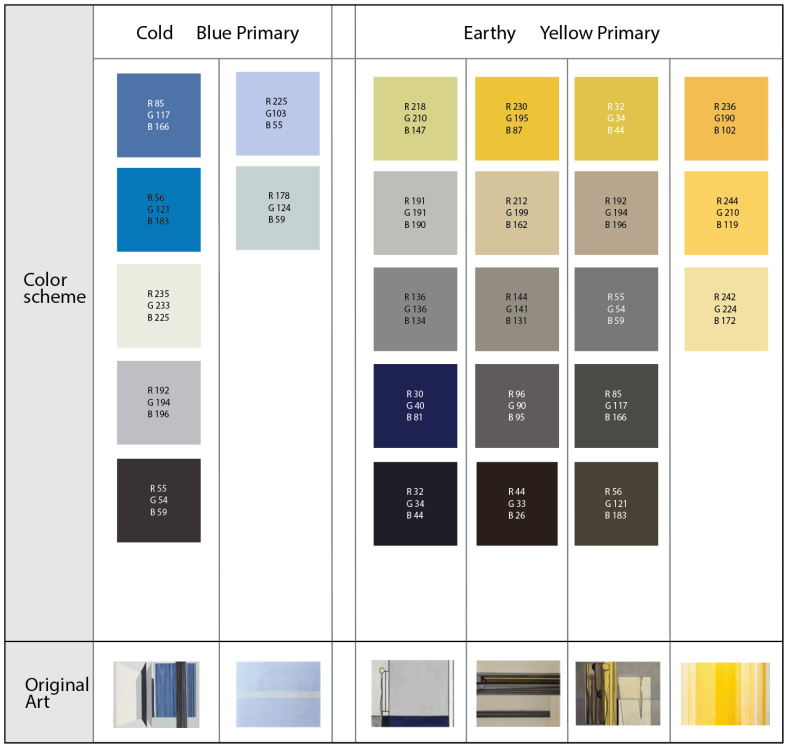


Table 4. 8

Color			
Color scheme	Harmonious Primary Monochrome Earthy Warm/Cold	Number of colors	Limited color of one drawing （One/two dominate color ）
		Color contrast	Extreme contrasts Dark brown - vivid red/orange Clashing Dark brown - vivid blue
Intensity of the colors	Vibrant Bright Vivid Pure Saturated Strong	Function	Expressing symbolic or thematic ideas Relationships with colors in surrounding environment Creating balance Creating rhythm/pattern/repetition

Table 4. 9

4.1.1.4 Visual elements process

The processing methods chosen to use in this project are addition, subtraction and transformation. This step is mainly to let the elements better works with the furniture function requirements. Designer can adjust and change, even create, some elements based on the analysis outcome or the furniture function.

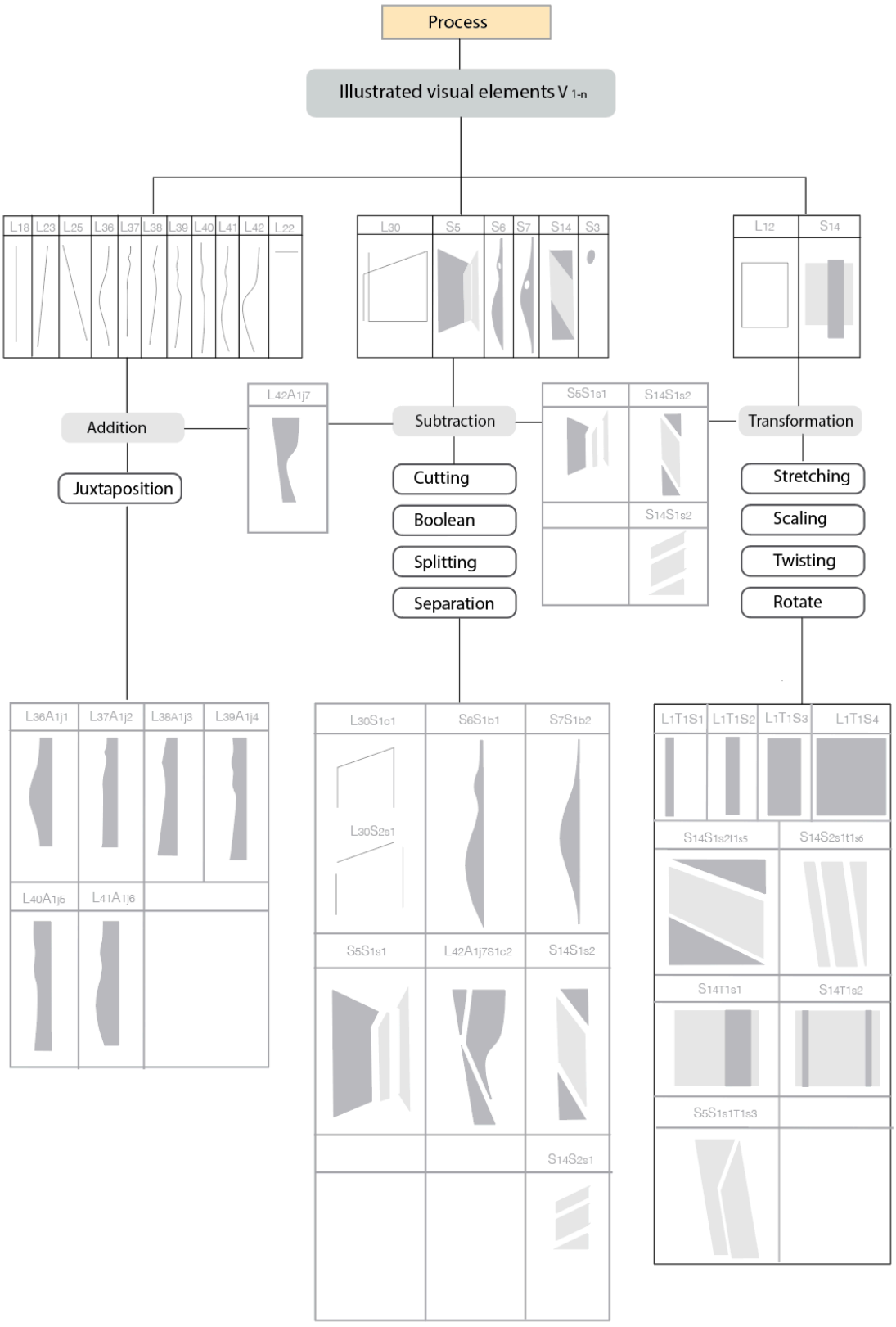

Process
Illustrated visual elements V 1-n
L18 L23 L25 L36 L37 L38 L39 L40 L41 L42 L22
L30 S5 S6 S7 S14 S3
L12 S14
Addition
Juxtaposition
L42A1j7
Subtraction
Cutting
Boolean
Splitting
Separation
S5S1s1 S14S1s2
S14S1s2
Transformation
Stretching
Scaling
Twisting
Rotate
L36A1j1 L37A1j2 L38A1j3 L39A1j4
L40A1j5 L41A1j6
L30S1c1 S6S1b1 S7S1b2
L30S2s1
S5S1s1 L42A1j7S1c2 S14S1s2
S14S2s1
L1T1S1 L1T1S2 L1T1S3 L1T1S4
S14S1s2t1s5 S14S2s1t1s6
S14T1s1 S14T1s2
S5S1s1T1s3

Table 4. 10

4.1.2 Furniture

The furniture chosen to interact with the art is the chair. The structure of the chair is mentioned in Chapter 2.4.4. The main joints are biscuit and dowel joint which can be found in Chapter 2.4.6.3. The components and the interaction results are showing in the Table 4.12.

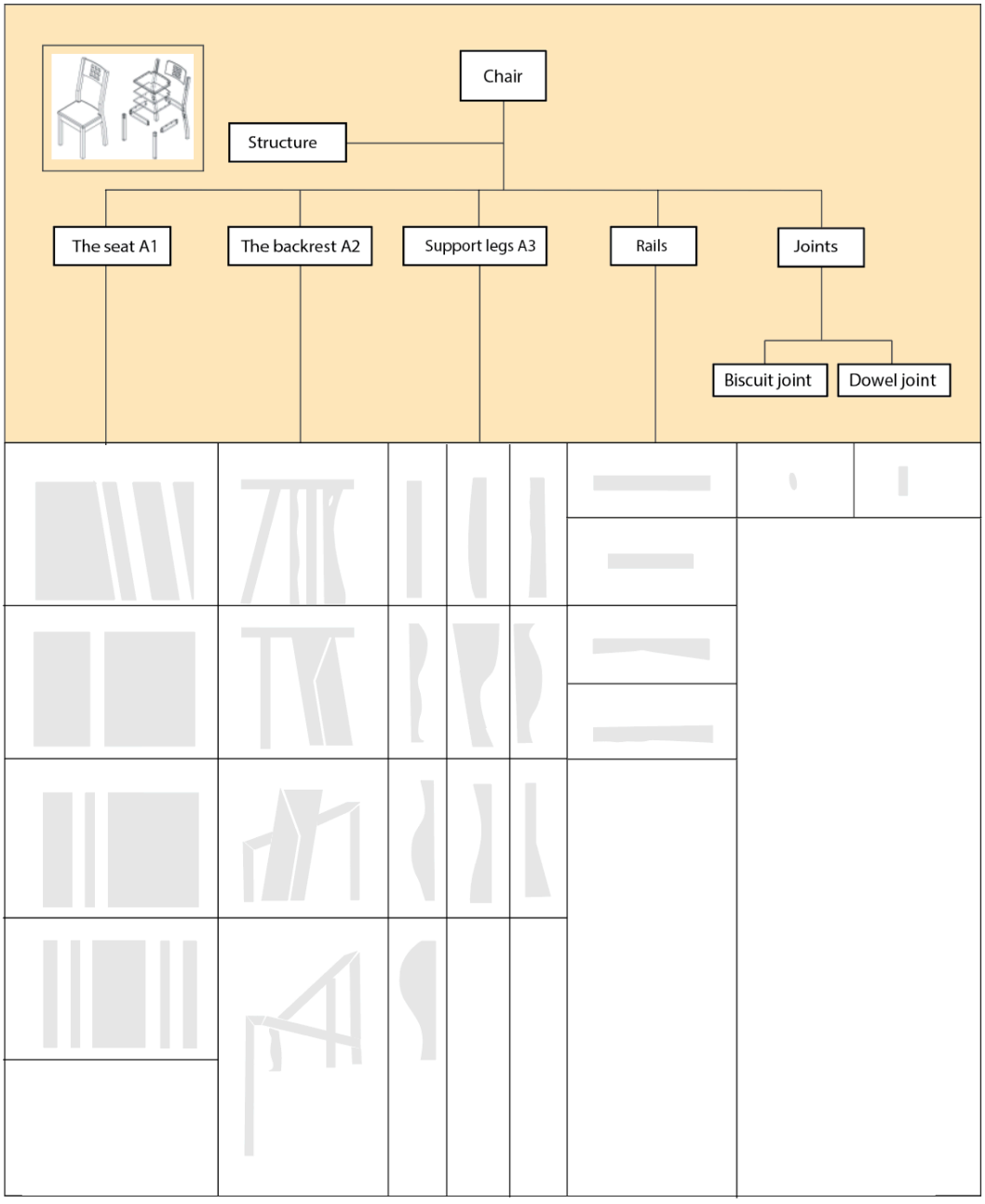


Table 4. 11

4.1.3 Design drawing

The concepts (Fig4.4-Fig4.13)are generated from integrating art conponents and furniture components. But it is not limited on the analysis outcome; the analysis outcome in this step can be used as reference. The designer still can generate totally different ideas as long as it is inspired by the art.

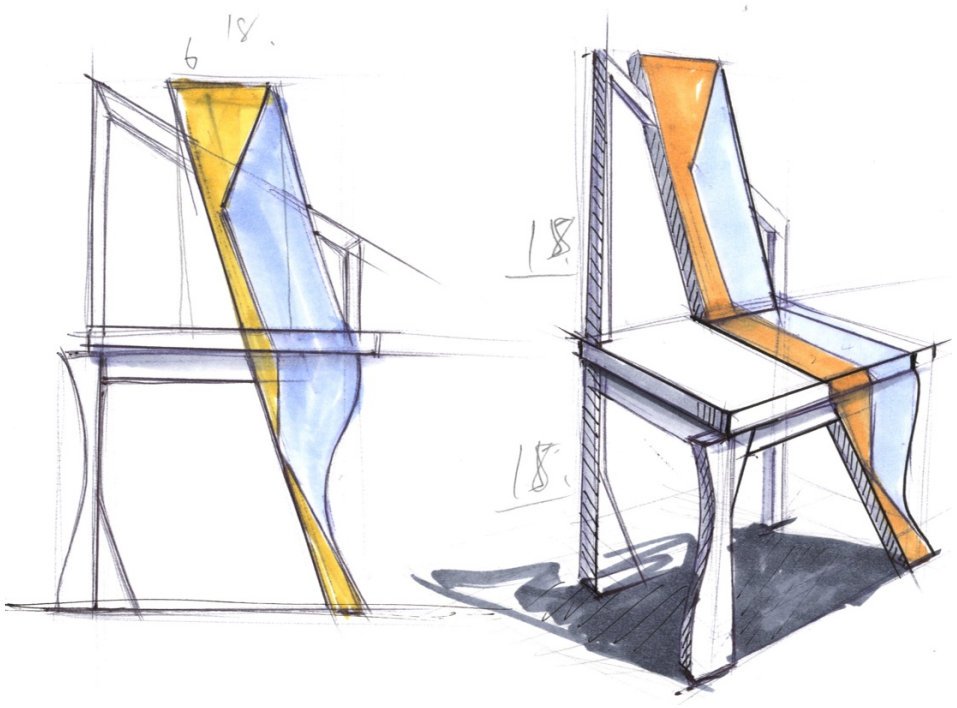


Figure 4. 4

Figure 4. 5

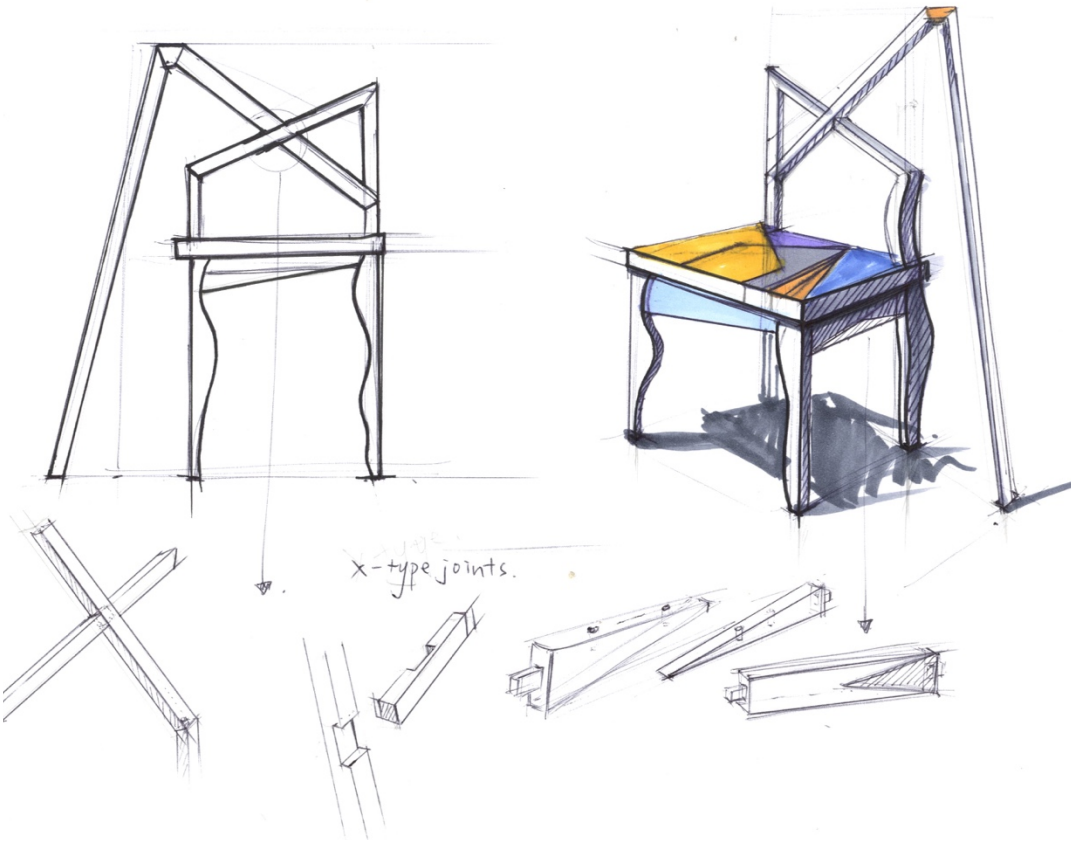


Figure 4. 6

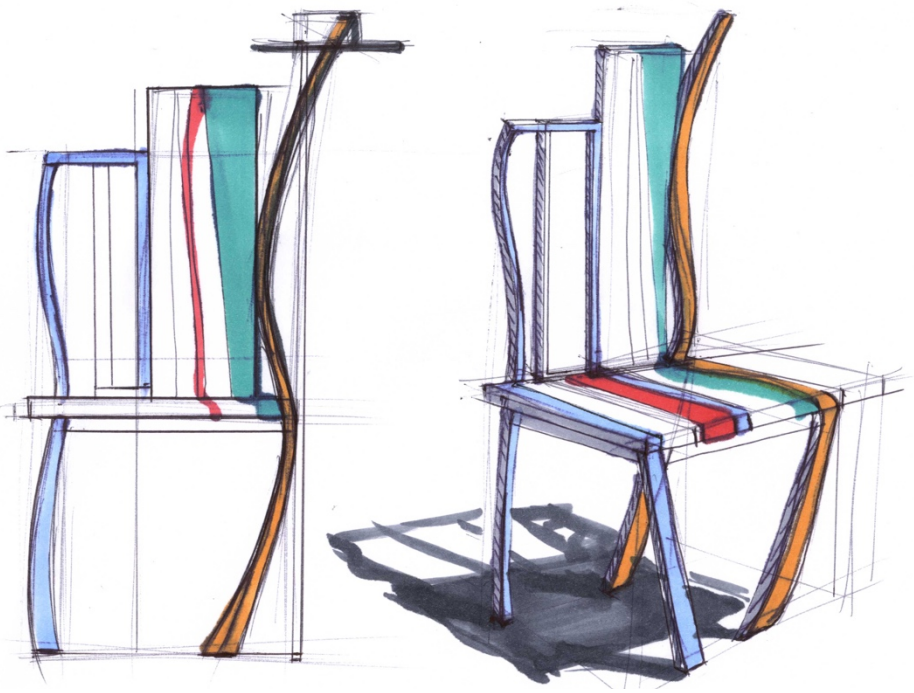


Figure 4. 7

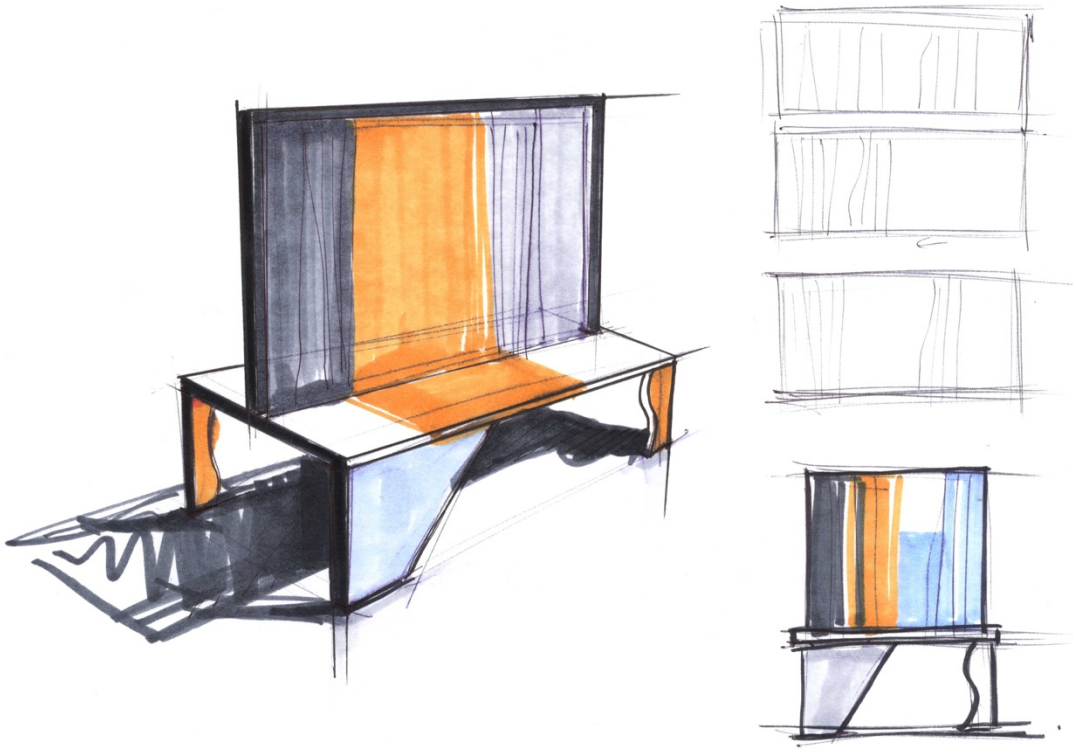


Figure 4. 8

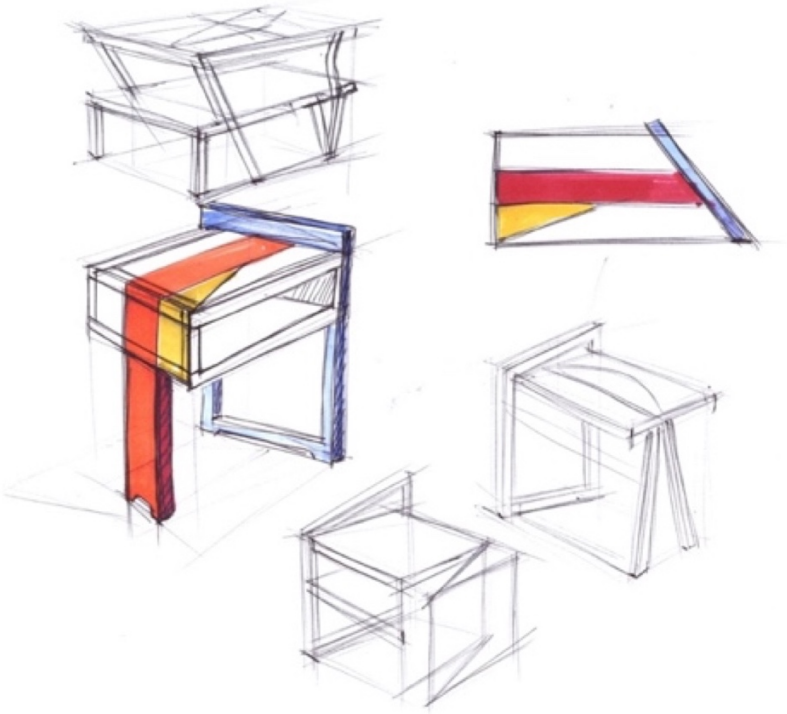


Figure 4. 9

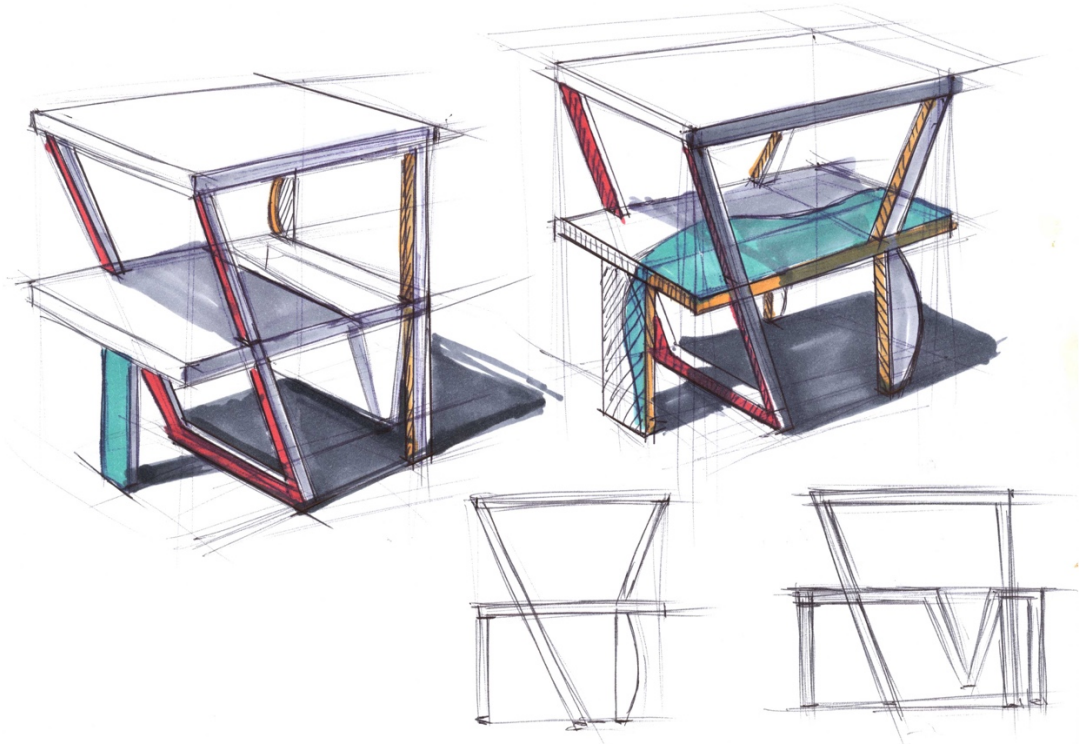


Figure 4. 10

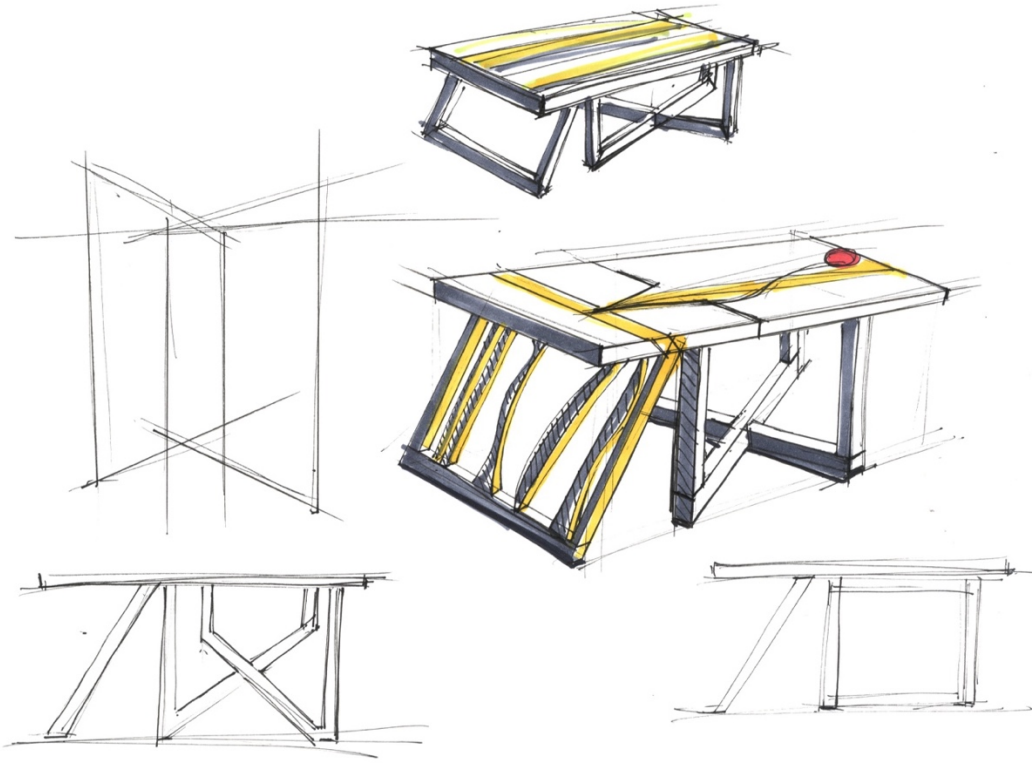


Figure 4. 11

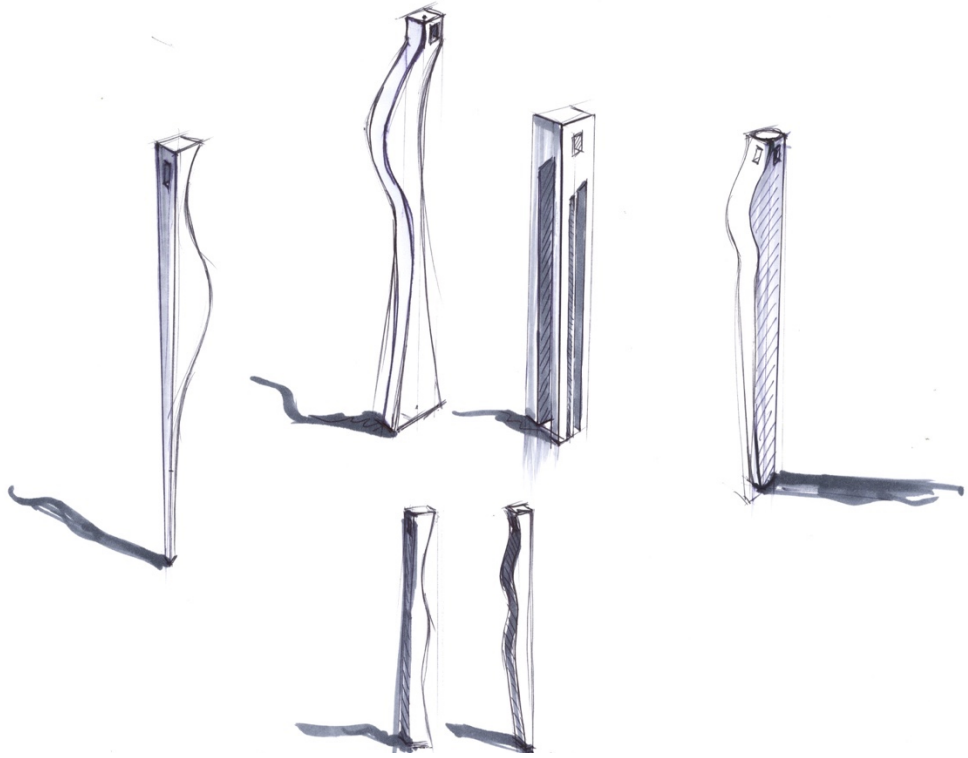


Figure 4. 12

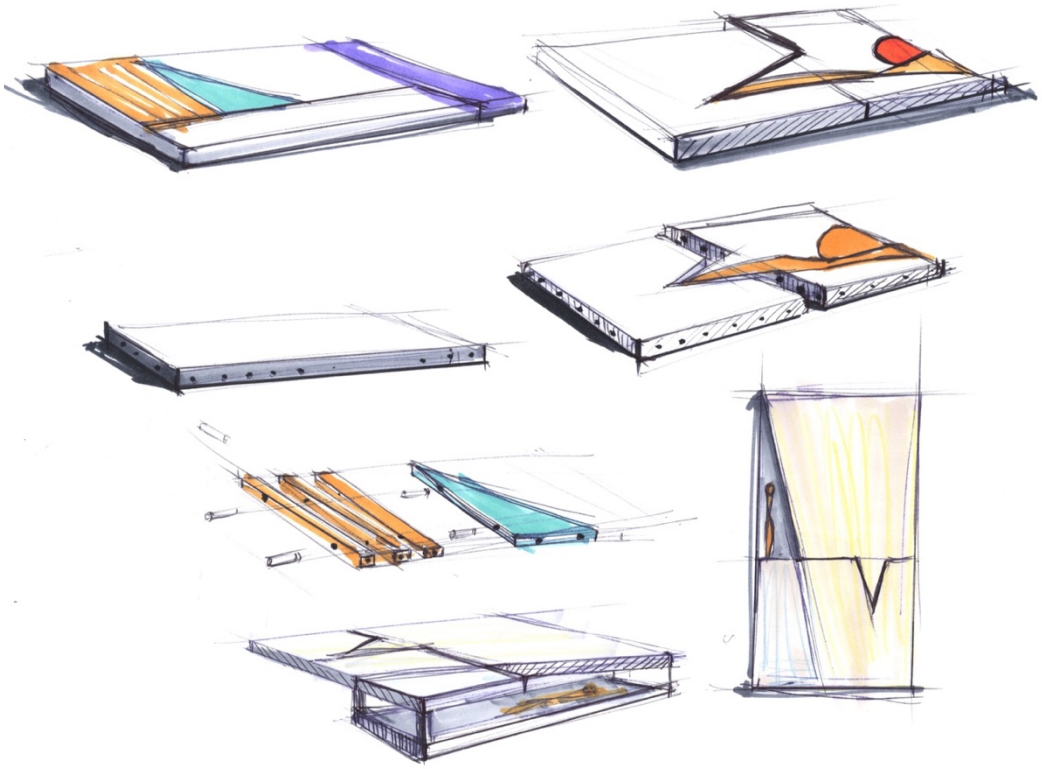
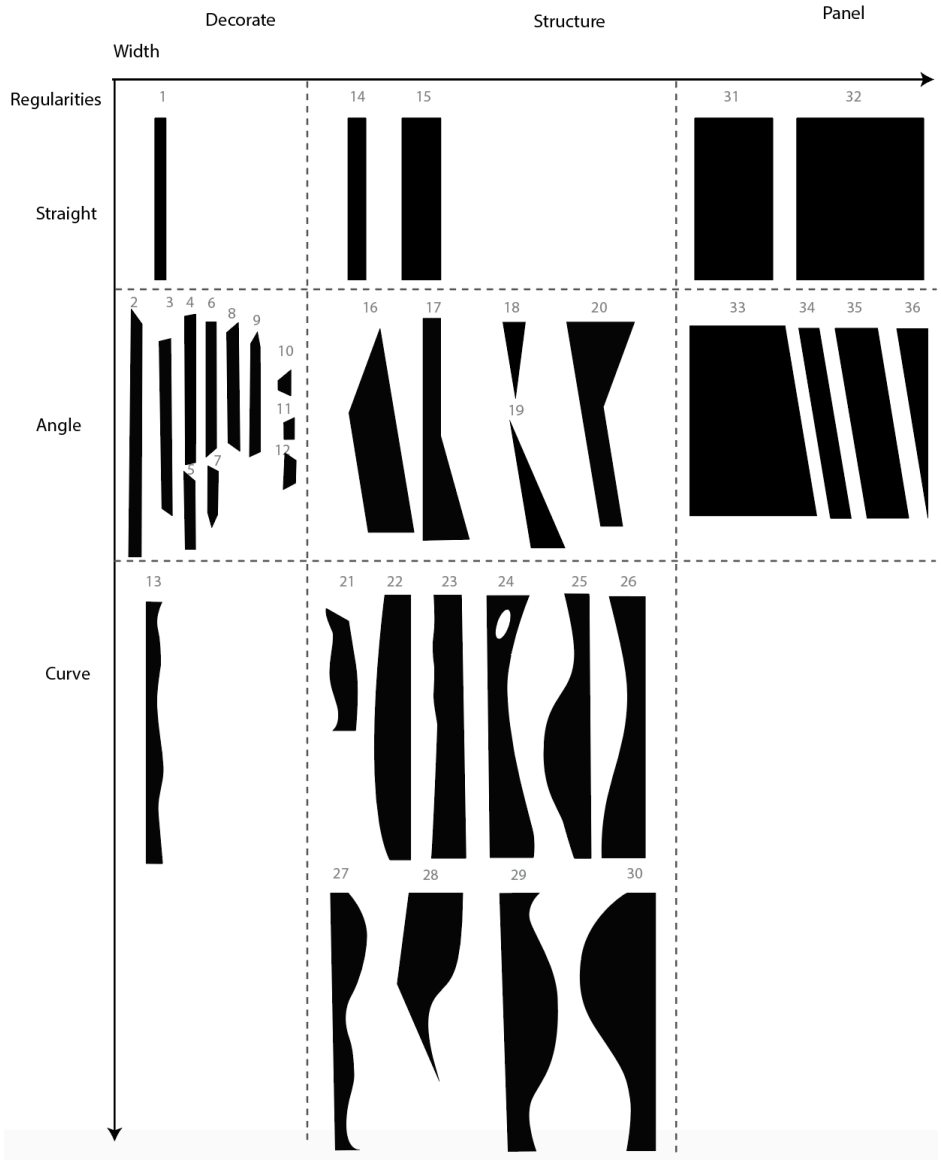


Figure 4. 13

4.1.4 Modularity

In terms of modularity, what needs to be considered here are the common modules and the modular connection types. There are three big groups of shapes, straight, angle, and curve shapes and considering the function decorate structure and surface decides the width and thickness of the components (fig.4.14).

Standardized common modular



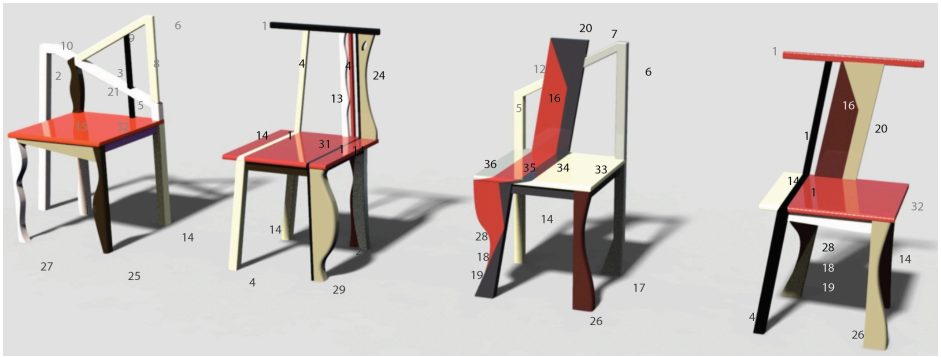


Figure 4. 14

There are two main connection types： the biscuit joint for horizontal relationship and dowel joint for L type relationship

Modular connection type

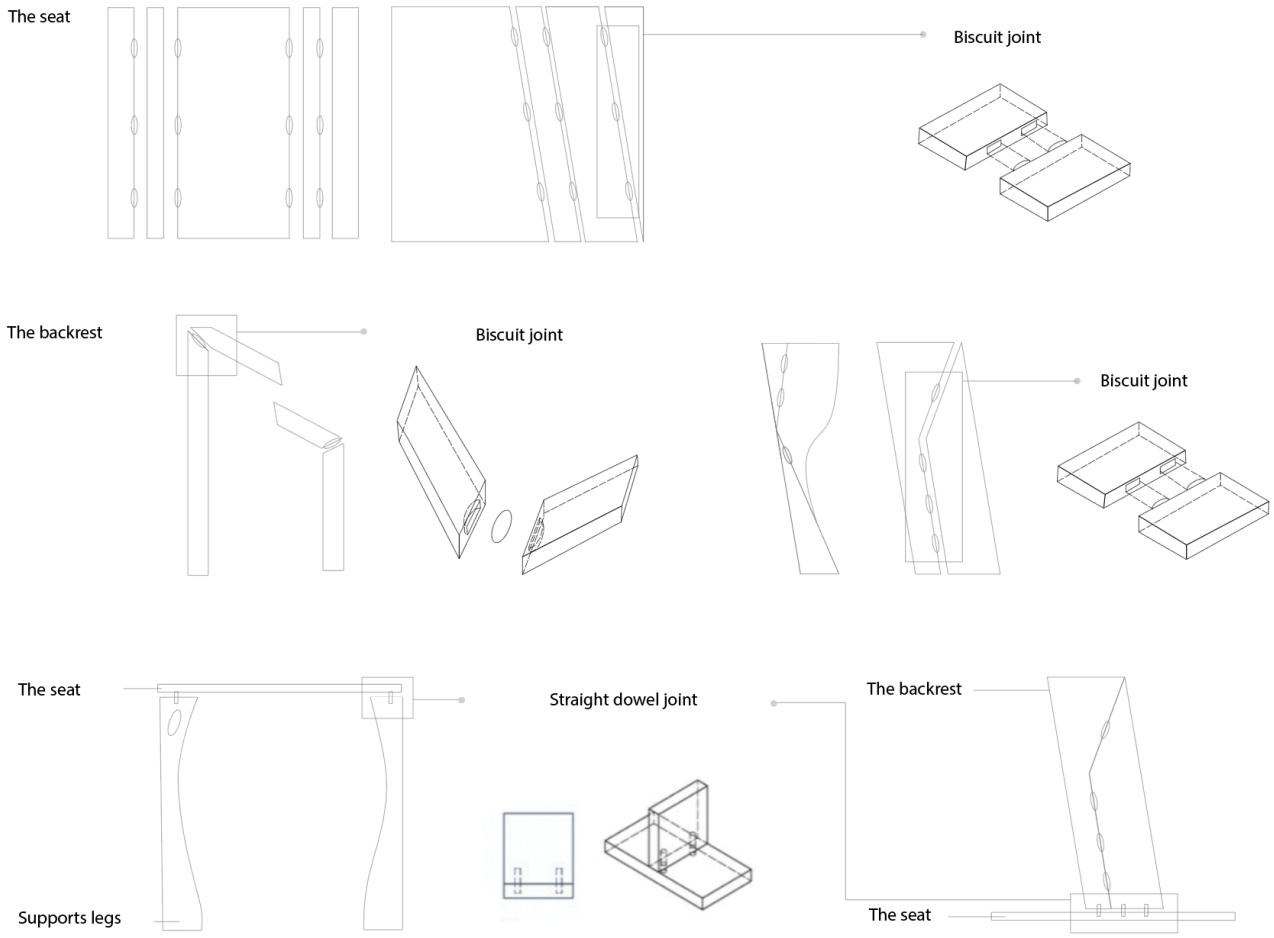


Figure 4. 15

4.1.5 3D Rendering

Figure 4.16 shows some examples of different combinations.

Figure 4. 16

According to the art color scheme from previous Table 4.7, the design could provide different color combinations for customers to choose or combine their own preference. Figure 4.17 shows some example of different color combination.

Figure 4. 17

4.1.6 Models

The process of making the models includes cutting the boards to the shape and sanding to fit every component together (Fig.4.18), putting the primer on the wood prepare for painting (Fig4.19), painting (Fig4.20), and assembling (Fig.4.21) .

Figure 4. 18

Figure 4. 19

Figure4. 20

Figure4. 21

Figure4. 22

Figure4. 23

Figure4. 24

Conclusion

This thesis defined abstract art, and study about art genres, the relationship with furniture design movements, the furniture components, mass customization and modular design process. Then conclude a way for designers to analyze and process with furniture components to design a family furniture for mass customization which costumers can pick their preferred components to combine their unique furniture without influence the manufactory.

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