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# The use of formal aesthetic principles as a tool for design conceptualisation and detailing

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**Abstract**
The practice and teaching of form-giving typically takes the starting point in enhancing the intuitive and explorative approach of form giving rather than employing available structured methods for generating form. In this paper, formal aesthetic principles are evaluated based on their potential to be applied in a generative manner. Literature studies have revealed 6 design principles, which are relevant for form development in a selection of design fields. These design principles were classified according to their connectivity with mathematical and non-mathematical theories. Although the Fibonacci sequence, Golden Ratio and Gestalt theories are most relevant for analysing and developing a balanced form, there is no evidence that these design principles were used as a guideline for designing new products or that they have been mostly applied for retrospectively analysing existing 2-D and 3-D products forms. With the potential of proactively using design principles for form studies in the conceptualization and refinement stages of the design process, design practitioners could utilise design principle templates to experiment with and determine balanced proportions as part of the design conceptualization work, prior to making design decisions mainly based on technical functionality, manufacturability and usability. This presupposes that these design principles can be used as a tool for analysing, generating and organizing new forms, which fit the working practice of the designer. However there is a risk that an overemphasis and over-reliance on geometric principles may restrict serendipitous creativity in form giving.

***Keywords: Formal Aesthetic principles, Form giving, Geometry, Gestalt***

## 1 Introduction

When people look at any complex combination of elements in design such as paintings or even the surface of a web design, we see the whole before focusing to the individual parts. This idea of seeing as a whole before focusing on the individual parts is closely related to Gestalt theory, which is fundamental for understanding both the geometric and semantic perspectives towards form giving. According to Behrens [1] Gestalt is a German word, which means "Shape or Form" .The Gestalt theorists were the first group of psychologists to systematically study perceptual organisation around the 1920's, in Germany . They were Johann Wolfgang von Goethe, Ernst Mach, and particularly of Christian von Ehrenfels and the research work of Max Wertheimer, Wolfgang Köhler, Kurt Koffka, and Kurt Lewin. The idea behind the Gestalt theory is triggered by the notion that the human brain tends to organize visual "elements in holistic, parallel and analogue ways. The Gestalt effect is the form-generating capability of our senses, particularly with respect to the visual recognition of figures and whole forms instead of just a collection of simple lines and curves. In psychology, gestaltism is often opposed to structuralism and Wundt. The phrase "The whole is greater than the sum of the parts" is often used when explaining Gestalt theory. This leads to situations that composition is perceived as a whole.

Behrens [1] also mentioned and discussed in his articles that the gestalt theory plays a key role in influencing art and modern design. Many examples showed how certain principles of Gestalt psychology, such as proximity, similarity, figure, ground closure, were used in interaction and 3-D product design. Furthermore, Akner-Koler [2], p2. Described form giving is a conceptual and perceptual process of product gestalt into a physical form, in other words emphasizing that form giving is an integrated aesthetic process within the overall realm of industrial design processes.

In this article, several topics affecting the development of geometry and form-giving and how they played an important role in the generation of 2-D and 3-D designs will be discussed. Firstly, chapter 2 elaborates the different ways of how people determine two dimensions design (2D), interaction design (web design), three dimensional design, as well as mathematical and non-mathematical theories related to specific contexts

Concerning geometry and form-giving, there are certain principles, which have a direct or indirect influence on products that designers design. Some of the designers, architects, engineers and artists have made these principles normative for their work. In the discussion and conclusion part of the article, the status of geometry and form giving concerning the design of three-dimensional products will be discussed in greater detail.

This paper problematizes the relationship between designers' typical approaches and the applicability of these theories for form-giving purposes which give rise to the following research questions:

1. Do designers use these geometric design principles in practice? If positive, how should they use it, and in what way do these principles integrate in a structured design process? If negative, how do designers construct geometrical form?
2. What are these principles of design and how does this influence the practice of form giving in different fields of design?
3. Which of these principles are most suited for the design of 3-D products and does the implementation of these principles lead to a more balanced overall design?
4. Are design principles to be used as a prescriptive guideline for designing new products or are they more suited for retrospectively analysing existing 2-D and 3-D products forms?

## 2. FORM GIVING, GESTALT AND GEOMETRY

Whenever form is being discussed, it converges to principles supported by gestalt theory. In Gestalt psychology, form perception deals with how humans perceive elements of an object and out of that develop a mental picture of the holistic arrangement through the perceptual organization of these elements. In accordance with gestalt [1], Max Wertheimer published "The theory form" in 1923, where he illustrated objects through abstract patterns of dots and lines, assuming that humans have the ability to constellate. Wertheimer´s theory on Gestalt is supported by Chou [3] as the latter claims that gestalt theory attempts to describe how people tend to organize visual element into group such as proximity, similarity, continuity, symmetry, and closure apart. Gestalt principles assist in organizing perceptual information into coherent patterns. This indicates that gestalt theory is a central theme in understanding the concepts and processes of applied aesthetics and form giving.

According to Dewey [4] form giving is a field of study, which addresses the understanding of meaning of elements, its relationships, and how these relationships are organized within a unified whole. This definition is aligned with the gestalt theory principles. Within the context of industrial design, Smets, et al. [5] stated that form giving is mainly concerned with features influencing the aesthetic outer appearance of artefacts and how these complements technical and user functionality as well as construction. Besides this, form giving also has a communicative role, whereby its aim is to not only present factual information but also elements of meaning.

The term form giving is derived from the Swedish and German words "formgivning" and "formgeben" which means to give form as well as colour, texture, sound etc. to concept, needs and desires of contemporary society Akner-koler, [2], p.21. Furthermore Akner-koler [2], p.16 defined the concept of form from an abstract perspective with the realization of concrete objects and organization of ideas. As a noun it refers to physical and spatial dimensions that a typical form occupies and activates. As a verb, it can be defined as a procedural activity of craftsmanship, supported by a cognitive process, that drive form giving process using aesthetic methods. She also classified form into two categories; geometrical and organic form. Akner-koler stated that, Sculptor Rowena Reed and Painter/psychologist Alexander Kostellow merged geometric abstractions and organic principles into their artwork. Reed and kostellow deconstructed visual abstraction from geometry into forms, movements and relationship with organic principles of growth, movement, tension, gesture, asymmetrical composition etc. Greet, [6]. Meanwhile In 1915, Wick, [7] mention that geometric form was introduced by Oscar Schlemmer to develop anthropocentric constructivism. He added, Oscar Schlemmer applied geometric abstractions to the body and choreographed dance movements to study the human body. He emphasized that it is important to learn abstractions through pure, abstract, geometric composition.

Kamehkhosh [8] said that geometrical principles can be used as a tool for analysing and organizing form, but should be applied in a proper way, because otherwise it would restrict creative thinking and form giving. Roztler [9] claims that people use geometry to create alternative visions that reflect the future. Reversibly, the study of geometric forms and structures, new abstractions and meanings may have influenced the modern art movement.
Nowadays to meet the needs of the increasingly demanding user, form development should be approached from multi-dimensional perspectives, such as colour, texture, sound, and technology. To be contextualized and integrated with material and technology, form development has become more functional and systematic. The ideological concept that forms giving are about "less is more" is being adopted and practiced in the design of products up till 1970s. By the 1980s from giving was replaced by a more internationally accepted term, which is Industrial Design.

As time progresses, "technology push" and "need pull" phenomena are not the only drivers, which determine the quality of life in developed societies. Adhering to present views on how "quality of life " can be pursued, the study of forms and form giving has entered a new era, where meaning making, identity building and branding are future areas for the designer to be engaged with, with respect to research and development. However, concerning the status of form-giving and geometry in design, mathematical rules and theories, such as Occam's razor, Hick Law, Fitts Law, Fibonacci sequence and Golden Ratio, should not be marginalised as a tool for form giving. They are to be explored in conjunction with semantic approaches to develop creative forms.

## 3. PRINCIPLES OF DESIGN

An extensive literature study was conducted to identify important design and ordering principles that may be useful for design practice. According to Huang [10] there are 12 principles that are commonly used by designers, engineers and artists to understand and arouse positive and emotional human reactions. The principles are Ochham`s Razor, Hick`s Law, Fitts Law, Fibonacci Sequence, Golden Ratio, Rule of thirds, Panto Principles, Mental Model, Tolerance for error, Signal to Noise ratio, Equitable and Flexible use law, and Law of perceptible information, Out of these 12 principles, 6 were selected, which were relevant for 2D and 3D form development. The design principles are, Ockham' razor, Hick law, Fitt's law, Fibonacci Sequences, Golden Ratio, Rules of thirds, and Gestalt. During the selection process, gestalt theories, such as pattern, contrast, unity, etc. were used as a foundation for selecting design principles, because of the semantic perspective which cannot be ignored when developing forms from a geometrical point of view. In this chapter the selected principles will be discussed and reflected upon using real-life examples, where possible.

### 3.1 Ockham's razor

According to Sugihara Hiroshi (1997) Occam`s Razor, is a 14th century mathematician, who has strengthened the law of parsimony, or the rule of simplicity. The principles stated that "Entities should not be multiplied unnecessarily". Occam`s Razor´s rule of thumb has guided some of the world`s best and brightest mind such as Isaac Newton. Huang´s [10] explanation about Occam Razor principle, re-emphasized that the solution of complexities should not be multiplied beyond necessity though its entities. There are two principles within of Occam`s theory, which are important. These are the Principle of Plurality and The Principle of Parsimony. In summary, Occam Razor´s is avoiding complexity in design, information transfer and development of instruction guides.

### 3.2 Hick`s Law

Hick`s law is developed by British psychologist William Edmund Hick. It is based on the principle that "The time it takes to make a decision increases as the number of alternatives increases" For example; the greater the number of alternative buttons, the longer it will take to make to select the right choices (Hick, [11]). (Huang [10]) Within the context of design, this law promotes the use of design methods to simplify decision-making in situations, where the designer is presented with multiple options. In practice, Hick´s law has fundamentally proven to be effective in the design of software menus, control display, way finding layout.

### 3.3 Fitt's Law

Fitt`s Law is a model of human psychomotor behaviour, which explains the connection between movement and transmission of information (MacKenzie, [12]) It is cantered on mathematical equations that are used to illustrate the time it takes to reach a target (Fitt`s, [13]), and is basically an empirical model that explains speed accuracy of human muscles. According to MacKenzie [12] Fitt`s popular model has been widely used and adopted in many research area including human factor, kinematics and interaction design. As earlier mentioned by Akner-Koler [2] form is conceptually determined by physical and spatial dimensions, as well as dynamic elements, represented through "time to move to the target", and "distance from the starting position to the canter within the target width"(Fitt`s, [13]). These dimensions are fundamental characteristics to be incorporated in the overall form giving of products and graphical user interfaces.

### 3.4 Fibonacci sequence

The Fibonacci Sequence, named after Leonardo of Pisa, who also went by the name Fibonacci, was formally identified in the early 1200s for the first time, but actually practiced by Indian mathematicians long before. Fibonacci numbers are closely related to Lucas numbers in that they are complementary to Lucas sequences ‘Golden Ratio” where arithmetic principles of the latter fuel Fibonacci sequence numbers 1,1,2,3,5,8,13,21,34,55… . Based on this same principles, they describe the characteristics of growth processes which can be found in nature, for instance in the leaf and flower position of plants. Fibonacci sequence is associated with spiral structures, which are prevalent natural elements, a tree growing in a helix-formed pattern. The mathematician, Wisner in 1875 proved that a spiral tree construction is an efficient way of maximizing the capture of sunlight. In nature, we can easily find that almost every living object embodies certain physical spiral characteristics and arrangements. This arises, for example, in left and right handed spirals with a ratio of 8 to 13 or 21 to 34 (all numbers in the Fibonacci sequence.) When dividing these numbers the result is always 1.618, which is known as "Phi" or the Golden Ratio. From the ancient time it is often been claimed that golden section is the most aesthetically pleasing point at which the line is sectioned. Consequently, golden ratio has been incorporated into many art works, architectural design and mathematical analysis.

### 3.5 Golden Ratio

The Golden ratio is actually similar in terms of mathematical relationships to the Fibonacci sequence. Leonardo of Pisa who introduced it to the Europe eight hundred years ago along with the decimal number. Elam [15] highlights that the Parthenon`s in Athens shows an example of how the golden rectangle has been used in proportioning its façade. The famous modernist Swiss architect Le Corbusier centred his design philosophy on the golden ratio and Fibonacci series. Elam [15] indicated that Le Corbusier explicitly used the golden ratio in the design of his modular systems to explore architectural proportions. Examples are shown in his work “The Modular-A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics”. According to Elam [15] Le Corbusier´s work, on geometrical principles are valuable to the designer, artists and architect, because of the whirling square characteristics of the Golden Rectangle, which is commonly associated with Phi, and therefore most suited in sub-dividing a main rectangular form or grid into multiple related rectangles and squares.

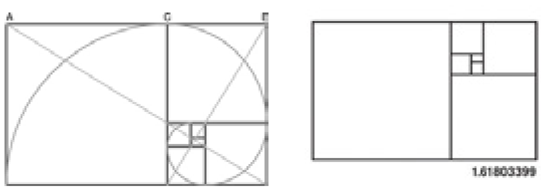



Figure 1: Golden rectangle, spiral associated with Phi.

### 3.6 Rule of third

The rule of third is one of the main rules in art and in photography composition theory. The principle is derived from the Golden Ratio theory and is based upon the proposition that the human eye naturally gravitates to intersecting points of an image that is divided into 3 x 3 sections. The rule of thirds is built upon an imaginary grid, comprising of two vertical lines and two lines horizontally, which crosses each other, making nine sections. Normally professional photographers capture any image using this Rule of third principle, because it always gives the best composition in a photograph.

## 4. DISCUSSION

Literature studies have revealed 6 design principles, which are relevant for form development in a selection of design fields related to 2-D and 3-D design. These principles are the Ockham' Razor, Hick law, Fitt 's law, Fibonacci Sequences, Golden Ratio, Rules of thirds, and Gestalt. Designer used geometric design principles as influences in the practice of form giving in the different fields of design. Geometric principles can be used as a tool for analysing and organizing 2D and 3D form. Golden ratio and Fibonacci numbers are commonly used design principles, based on mathematical ratios that were instigated by nature to create 2D and 3D form compositions. The golden ratio is found to be most relevant to achieve beauty and balance in 2-D and 3-D design and 2-D art. In 2-D art for example, Leonardo da Vinci, made extensive use of the golden ratio in his painting "The Last Supper" image (a).All dimensions in the room, including table with the proportion of people in his painting were based on the Golden section. Meanwhile Salvador Dali in his famous painting "The Sacrament of the last Supper" image (b) following Da Vinci framed his painting in a golden section Rectangle. Dali positioned the two disciples at Christ`s side at the golden section of the width of the composition.

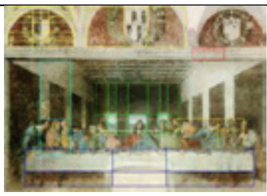
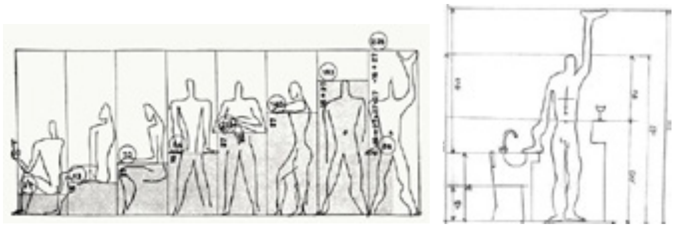
| "Last Supper" Leonardo da Vinci | "The Sacrament of the last Supper" Salvador Dali. |
| --- | --- |
|  |  |
| Image (a): Golden Section. | Image (b): Golden rectangle. |

Figure 1: (a) "Last Supper" Leonardo da Vinci. (B) "The Sacrament of the last Supper" Salvador Dali.

The golden Section is a low of proportionality. Some studies of the Acropolis, including the Parthenon façade can be circumscribed by the golden rectangle. It might indicate that the architects were aware of the golden ratio and consciously employed it in their design. In architecture Le Corbusier used the Fibonacci sequence to design integrative systems comprising of human proportions and sizes, sitting postures and sitting objects. Le Corbusier`s two books, Le Modular I published in 1948 and Le modular ll 1955 argue that harmonious proportions are important for everything, from the sizes of the cabinets and door handles to buildings and urban spaces. Fibonacci sequence as known as phi has contributed significantly in elevating the aesthetics, balance and harmony of some of the world`s greatest art works and architecture.

(a)



(b)

Figure 2: (a) Parthenon façade. (b) Le Modular I published in 1948 and Le modular ll 1955. Le Corbusier`s two books,

Designers have identified important design and ordering principles that may arouse positive and emotional human reactions. Concerning industrial design, the Golden Ratio principle has proven to be useful in improving the aesthetic impression of a product by stressing on harmony and balance of elements and features of the overall form (Avramovic, et.al [16]). An example of how this principle has been applied in Industrial Design is shown in the case study of the subjective aesthetic preferences of consumer's household appliances, vacuum cleaners. In this case study, the golden ration has merely been used as a prescriptive tool in the design of an unknown vacuum cleaner. There is no indication that the golden ratio has been adopted as a design tool for the other 5 vacuum cleaners (Avramovic [16], p.32, fig 6). However, the authors suspect that the golden ratio may have been used retrospectively to analyse the Dyson dc19t2i.

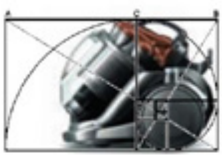
| Dyson dc19t2i | unknown vacuum cleaner |
|---|---|
|  |  |
| Image (a): golden ratio matched onto vacuum cleaner. | Image (b). Golden spiral construction |

Figure 1: (a) Dyson Vacuum cleaner. (b) Golden ratio been used as a prescriptive tool in design.

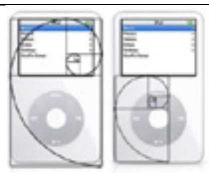
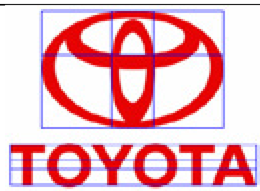
| (a) Hewlett Packard calculator | (b) IPod classic | (c)Toyota logo | (d) Il Conico kettle |
|---|---|---|---|
|  |  |  |  |
| Golden Section Rectangle | Golden ratio 1:167 | golden ratio | Geometrical structure |

Figure 3: (a) Hewlett Packard HP12C Financial calculator. (b). IPods classic 5G model (c). (d) Product logo of Toyota (e) Aldo Rossi´s ll Conico kettle.

Another Industrial Design example, where the Golden Ration has been adopted, is the Hewlett Packard HP12C Financial calculator, which was introduced to the market in 1982 as a part of the HP Voyager Series. The official dimensions on the HP site were closer to the 1.618 proportional rations of the Golden Section. In this case, the dominant sub-categories of the Golden Ratio, which were used to design the HP 12C Financial Calculator, were the Golden Section Rectangle and Square Construction Method. To underline the relationship between economic success and geometric methods, Akhtaruzzaman et al [17] reported that Apple was had increased its sales of iPods NANO from 6 million in 2005 to 14 million in 2006 because of the application of golden ratio principle along with other support products. Similarly, the classic 5G model led to a significant, sales success, approximating 2 times that of its predecessor, the 4G. Another example is the Toyota logo, comprising of three ovals. Two perpendicular ovals actually represent the relationship of customer and Toyota. These two ovals combine to form "T" for Toyota. The ratio of the both horizontal and vertical ovals is approximately 1.613 (Golden Ratio) and symbolises a divine relationship between the customer and the company. The final Industrial Design example shows how Aldo Rossi´s ll Conico kettle, which is composed by basic geometrical, shapes and forms one unified functioning entity, adheres to a geometrical structure that uses a 3 x 3 grid (Elam, 2001).

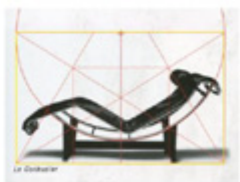
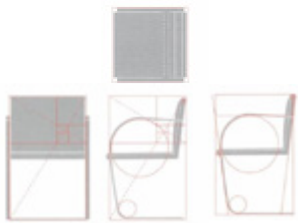
| Chaise Longue (Le Corbusier, 1929) | cantilever armchair | Mies van der rohe´s |
|---|---|---|
|  (a) |  (b) |  (c) |
| Golden rectangle | Golden Section Rectangle | |

Figure 4: (a) Golden section applied on Chaise Longue (Le Corbusier, 1929). (b) Golden Section Rectangle predominantly applied in defining the proportions of the side and frontal views of the cantilever armchair. (c) Mies van der rohe´s cantilever armchair, or MR chair.

In furniture design, the use of the Golden Ratio has been exemplified in Mies van der Rohe´s cantilever armchair, or MR chair, which was designed in 1926. According to Elam [15] several geometrical methods belonging to the Golden Ratio group were used to analyse the design. As a result the Square Construction Method has been used in the top view to define the chairs proportions, whereas the Golden Section Rectangle was predominantly applied in defining the proportions of the side and frontal views of the chair. Le Corbusier also represented the divine proportion onto his design, Chaise Longue in 1929. The harmonic subdivision of a golden rectangle shows that the width of the rectangle becomes the diameter of the curved frame of the Chaise Longue.

The Golden ratio also found on the design of the Volkswagen Beetle [15] the Volkswagen Beetle is a good example where Golden Ratio principles have been matched in transportation design. In this particular example, the body fits neatly into the top half of the Golden ellipse and the side windows also repeat the shape of golden ellipse with the door. This case example does not only illustrate the relevancy of using Golden Ratio principles in transportation design but also demonstrates that certain methods belonging to the Golden Ratio, such as the Golden Ellipse are more suited to proportion curved shapes.

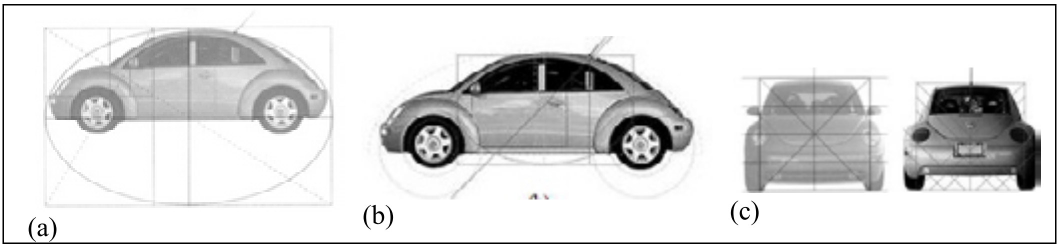


Figure 5: (a) (b) and (c) The front and rear view of the car are almost in a square with all surfaces symmetrical.

**CONCLUSION**

Literature studies have outlined the relevance of geometric methods for form development in interface, product, transportation and furniture design. These geometric methods can be classified according to 6 design principles, based to their connectivity with mathematical and non-mathematical theories. Concerning non-mathematical founded design principles, such as the Fibonacci sequence, Golden Ratio and Gestalt theories are most relevant for analyzing and developing a balanced form in 3-D product design. Having a background from design practice, the authors strongly advocate the use of the Golden Ratio, as it is natural, aesthetically pleasing and most versatile. Design principles, which are founded in mathematical theories, are predominantly used in web- and interface designs.

The authors are of the opinion that an overemphasis and over-reliance on geometric principles may restrict creativity in form giving. However, no documentation has been found about cases, where the application of design principles did not contribute or even had a detrimental effect on the design output. Consecutively, they also question whether design principles are to be used as a guideline for designing new products or that they are more suited for retrospectively analyzing existing 2-D and 3-D products forms. For example, the incidental match of curves, rectangles and squares of the Golden Ratio with product forms, needs further validation to ascertain whether this design principle has been applied genuinely to prescriptively develop creative forms. If design principles are presently mainly used to retrospectively analyze form and form proportions, the authors foresee great potential to proactively and prescriptively use them in form studies in the conceptualization as well as refinement stages of the design process

More concretely, it can be concluded that design practitioners should experiment with design principle templates to determine balanced proportions as part of the design conceptualization work, prior to making design decisions which are merely based on technical functionality, manufacturability and usability.

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