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DESIGN PRINCIPLES IN NATURE

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Abstract. The form-shaping elements, the proportion and the rules of nature have been present in the machine and product design since their beginning. The main reason of this is that the message conveyed by a product design may often become the key to the overall success of the product, thus the designer should return to natural forms rooted deeply in the back of customers' minds. These forms undergo constant changes, yet they carry reliability recalling the living world that carries stability of the existence. This paper focuses on its outstanding role, potentials hidden in the form design and the opportunities of form bearing elements that have already been proved to operate in the nature.

Keywords: natural structures, bionics, design principles, natural adaptation, form, pattern, colour

1. INTRODUCTION

Defining the product's design forms in product development has become of increasing importance in the planning process in the past few years. The main objective of profit-oriented companies is to make profit by designing a product which is appealing to consumers, meets their needs or is likely to do so and sells well. In order to have a constant revenue, novelty should be maintained for the sake of appearances. This is achieved by a completely new design and not by further developing the functions that have a technical content.

2. NOVELTY FAKE

The "facelift" that has widely been used in the automobile industry is a good example of novelty fake when car models that have been on the market for several years undergo a facelift. This facelift trick does not involve any considerable technical changes, but just prolongs the life cycle time of products to some extent.



a) b)

Figure 1. Renault Mègane II a) Before facelift: 2003–2006, b) After facelift: 2006–2009

It is clearly seen from *Figure 1* that Renault Mègane II has undergone a facelift since both the front grille and the bumper have been redesigned. As for the version of Clio II manufactured since 1998, the changes in its form are even more exciting. Despite the fact that the assessment of the third generation of Clio is about to finish and the launch of Clio IV has already started, the manufacturer of Clio launches Clio II in South America retaining the old techniques without performing any changes in the form. It is quite common in the automobile industry to prolong the life cycle time of cars this way. What is extraordinary is that a relatively old model receives design elements of a new Renault image, which is about to be launched on the market. In order to achieve economic efficiency and to maximalize the utilisation of the production line, only a few product attributes have been redesigned such as the bonnet, the boot lid, the bumper and the lights. Other elements and the technical content remained unchanged.



a) *b)*

Figure 2. Renault Clio II a) After first facelift: 2001–2006, b) Post facelift: 2012

3. THE ROLE OF FORMS IN THE PRODUCT LIFE CYCLE

In the broad sense of the word, the product life cycle is the period of the time the product is available on the market. Similar to the life cycle of living beings, the product life cycle has several stages where the form plays an important role and has a considerable impact on sales. In the *introduction stage* when the product is introduced to consumers, the form acts as novelty and bears basic dimensions, thus this is the best time for making the public accept the product. In the second stage, the *growth* stage, the product already generates profit the amount of which depends on the form. This is highly influenced by the image shaped about the product. The reliability or even its appearance arising from form is sometimes more important than real and value increasing functions. In the *maturity* stage minor changes in form may delay the beginning of the last stage of the product life cycle, namely the decline stage discussed in the previous chanter. The performed changes will result in gaining some valuable time that can be spent on designing new products, whose developing process may be finished by the time the old product is withdrawn from the market.

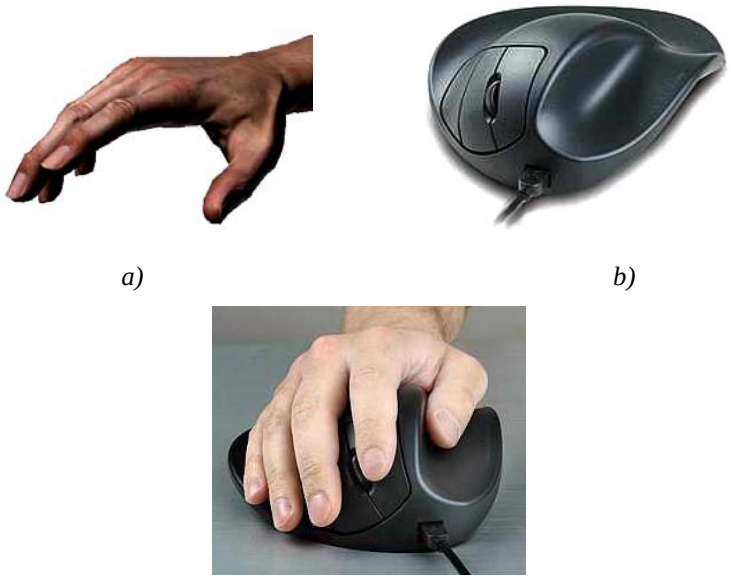
The role of design strategy is becoming more and more important so that it can meet the consumer's increasing need for novelty. Since consumers' demand changes more rapidly than in previous years, both the life cycle of a product and the time to be spent on designing

a new product gets considerably shorter depending on the market segments. It is more economical, easier and simpler to redesign the product form, colour and appearance than to invent new functions, materials and technologies or to further develop the available ones.

4. TIMELESS DESIGN FORMS

When a design form of a product is created, referring to "the always fashionable nature" is a good idea in almost all cases, not depending on the prevailing fashion trends. This can be a simple pattern or a combination of colours, a stereotypical design form element or a conventional dimension. The success of products designed this way lies in the fact that these natural design form creating elements acting as well-established form and function carriers that exist in consumers' mind consciously or unconsciously represent reliability and durability. Since they represent values that most consumers are looking for while purchasing a product, it is worth copying the nature and learning from it.

The act of copying the nature should not be considered as if the consumers were cheated. When the use-value of a product is assessed, it is common and fundamental to take into account the users' needs, body structure or movements required to perform functions. A right-handed tool or device is adapted to the size of users' right hand or possible movements (*Figure3*).



a) *b)*

c)

Figure 3. a) Model of the right hand, b–c) Handshoe Mouse manufactured by Hippus

There is also a psychological approach to target groups when a product is designed so that users can identify themselves with it as soon as they see it. Consumers are pleased to purchase and use products that are able to trigger positive feelings in them, which results in accepting shortcomings or technical functions of these products.

The colours and materials of the table resembling the shape of a flower illustrated in *Figure 4* recalls nature. Its simple organic forms attract the target audience that appreciates innovative objects. Another peculiarity of this table is that it consists of five similar elements that are supported by an ordinary wooden structure without any glue or fixing elements and a simple glass surface.

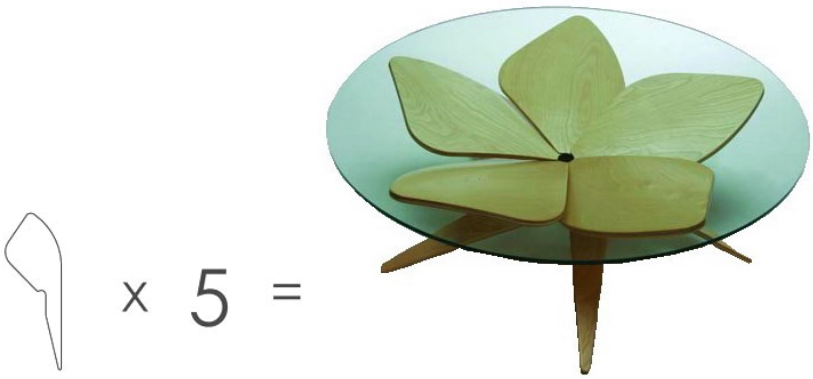


Figure 4. Wood-and-glass coffee table design by Shige Hasegawa

In some cases designers both draw inspiration from the nature and attempt to produce an exact replica of it. Instead of simple design form elements, he moulds complex formations or structures of living beings and pays special attention to precise description of details. The lion-shaped sewing machine shown in *Figure 5* is not used. It serves as a decoration in the room, but can be easily transformed in to a sewing machine. This is rather applied arts than organic design.

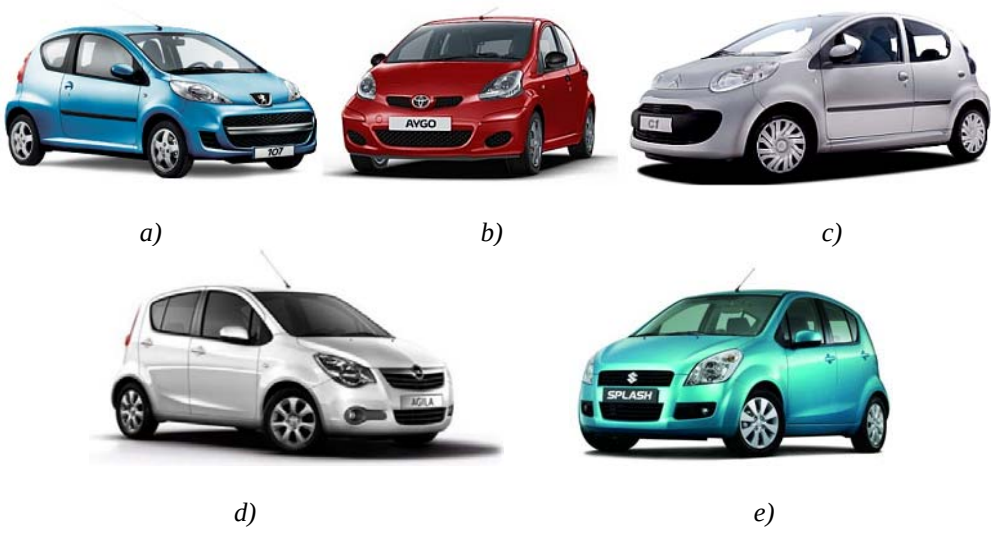


a) *b)* *c)*

Figure 5. a) "Lion Singer" sewing machine from 1868 by Kimball and Morton Company b–c) Operating-board of the "Lion" treadle lock-stitch sewing machine

5. PSYCHOLOGICAL ROLE OF FORMS

There are very few innovative and technical solutions both in the down and middle market products in the automotive industry that differ from competitors. Nevertheless, consumers prefer particular brands to others. Products of different manufacturers differ only in design forms in many cases. Moreover, only logos are different in some down market products. It is obvious that buyers make decisions on the basis of their emotional attachment when purchasing products like that and gives preference to a brand and a design form which is more appealing that the competitors'. That is the reason why manufacturers conduct product development with other brands and even with potential competitors. They appear on the market with products having similar technical solutions developed in cooperation, but different built-in materials. They build on the loyalty of established consumers, on the company's name and brand specific design forms. Companies manage to decrease development costs significantly when developing a product in cooperation and generate profit by well positioning the members of a product family. *Figure 6* illustrates the results of two valuable cooperations. It is clearly seen that the basic dimensions, the main lines of the doors and windows are similar, but the lights, the bumpers and the mud-guards are quite different and belong to different brand images of down market small cars that target different audience.



a) *b)* *c)*

d) *e)*

Figure 6. a–b–c) Family of Peugeot 107, Toyota Aygo and Citroën C1
d–e) Opel Agila and Suzuki Splash twins

6. DESIGN AS A SOURCE OF INFORMATION

When users get into contact with a product, they create their first impression based on the product appearance. Consequently, the impression created by forms and colours is of great importance, since it may have an impact on the image of the product function in the future.

6.1. Forms

Design forms may market the product *as high-tech. modern, conventional and retro*. It may illustrate the applied technology or highlight the quality of used materials. The *symmetry* of main elements may carry information transmitted by forms, which suggests reliability. An element placed asymmetrically raises attention to one of the main functions by highlighting it visually, whereas dissection may highlight particular units of different parts. By careful selection of straight and curved lines and surfaces form contrasts can be achieved, which can also be dissected. By using repeating regular form elements, rhythmical appearances create the feeling of considerateness and order in customers.



a) *b)* *c)* *d)*

Figure 7. Handling operators:
a) press-button, b) puller, c) rotary switch, d) tumbler switch

Using these design principles we can achieve, for example, to draw a conclusion on the basis of the shapes and striations of different buttons about the movements needed for usage. These are very important pieces of information that should be available during the usage independently from the product description. The shapes of press button, puller, rotary switch and tumbler switch can be recognized easily and they serve the above mentioned aim (*Figure 7*).

6.2. Colour scheme

Beside the shape, colour scheme is also the part of the design, since the designer is able to express information in the same way as colours have outstandingly important signalling and warning functions. Association of ideas are instinctive in people, because they are deeply coded in them. If fire is mentioned, for instance, the so called luminous flame (having the shades of orange and red depending on the proportion of oxygen, coal and hydrogen, but within a relatively narrow range of colour) occurring at burning materials rich in coal, comes to most people's mind. Contrary to this, ice as the most common cold medium, appears in the shades of blue. This way we consider the shades of red to be hot and the shades of blue are considered to be cold. Even the fact that nowadays we more frequently see the

blue flame in gas appliances (which forms at the perfect burning of methane) would not change this attitude.

According to this, if a surface is hot and we want it to be felt hot, the most appropriate thing is to use the shades of red. People's mood can be influenced by the basic principles of colour dynamics, or we can even compensate the sense of heat, noise and smell occurring due to environmental effects. For instance, the shower with blue and red LED lights in *Figure 8*, affects not only the user's mood, but the sense of heat can also be increased by a few degrees if we use the appropriate colours.



a) *b)*

Figure 8. LED shower a) with BLUE light, b) with RED light

The use of full colours suggests dynamism or the wish to play. The most important functions can be highlighted by bright colours in a colour scheme with grey. The combination of yellow and black is one of the most appropriate options used for drawing attention to something. Since the living world also uses it due to its outstanding colour contrast for warning, it is also suitable for drawing attention to artificially developed engineering objects (*Figure 9*).



a) *b)* *c)* *d)*

Figure 9. Black and yellow signs:
a) wasp, b) salamander, c) speed bump, d) caution board

While studying the contrast of different colours we should not forget about the phenomenon of the simultaneous contrast effect, which was one of the greatest observations made by Leonardo da Vinci. Its main point is that "*an object seems to be less light among the same light objects if its surroundings are the most white and that is the object to seem more white if the background is darker.*" It can be said about the whole spectrum that in reality all colours are considered to be different due to the background.

Using this phenomenon we can compensate a discoloration or difference in shades appearing due to technology with a well chosen background colour. The other scope of application of this phenomenon occurs, for example, when the same medium grey buttons are used with dark or light background. This way significant cost saving can be realized by decreasing the number of spare tools despite the product's several, even strikingly different colour scheme, In certain cases colours and shapes are used similarly to animals for hiding away in the environment. The main point is that we choose the colour of a spare part so that it would assimilate with the environment. For example, wires, cables and other equipment of a room or machine can optically be hidden.

6.3. Design as marketing

An important feature of the information package behind the design is that it gets to the user in a nonverbal way, and the user feels it much more authentic as he does not read about it in a description popularizing the product, but he finds it out by himself. Therefore, certain data of the product description serve to enforce the impressions based on the shape and colour. That is why we should make an effort to achieve the harmony between the functions and design, because without this the product will promise something else by its design not the things that it can offer to the user.

During the product designing process it is emphasized that signals transmitted by the design should be clear for the widest range of consumers. It is important that the clear message of design elements bearing information would depend – to the least extent – on the sex, age, education, social and cultural or geographical sense of belonging. It is obvious that it offers a firm solution to such a design task if we start with coded impressions instinctively developing in people.



Figure 10. a) Shape of falling drop b) "Las Crono 2011" long tear drop shaped aero helmet

In *Figure 10* a helmet having the shape of a falling waterdrop can be seen. It is not only streamlined, but its extra shape elements and dynamic paint makes this property even more

visible. This aerodynamically perfect shape was inspired by nature. Its developers found the solution of minimum function of drag coefficient in the dynamically deforming shape of the falling plastic liquid drop.

7. SHAPE ELEMENTS

Forms most often consist of basic geometric shapes: *point, straight line, flat surface, circle, square, cube, prism, pyramid, cone, sphere, cylinder* etc. All of these shapes can easily be interpreted, they are regular, and these features result in a shape suggesting reliability. However, amorphous and complicated shapes are recurrant motifs, which are used by the designer to suggest movement, creativity, ease, or naturalness, since geometric shapes are rarely clear in nature. Despite this fact basic geometric shapes can also be used effectively, unless we forget about the messages of *proportion, rythm, symmetry, orientation, articulation, or shape contrasts*.

The build, proportions, size or even colours are subjected to the functionalism needed for sustainment. The minimum usage of material and energy appears to be an important subtask beyond basic functions. Similarly to the living world, expediency is a primary aspect in the case of everyday objects, this way basic proportions are also defined by functions. Within it, the designer still has the opportunity to create the final shape of the product with eye-catching proportions.

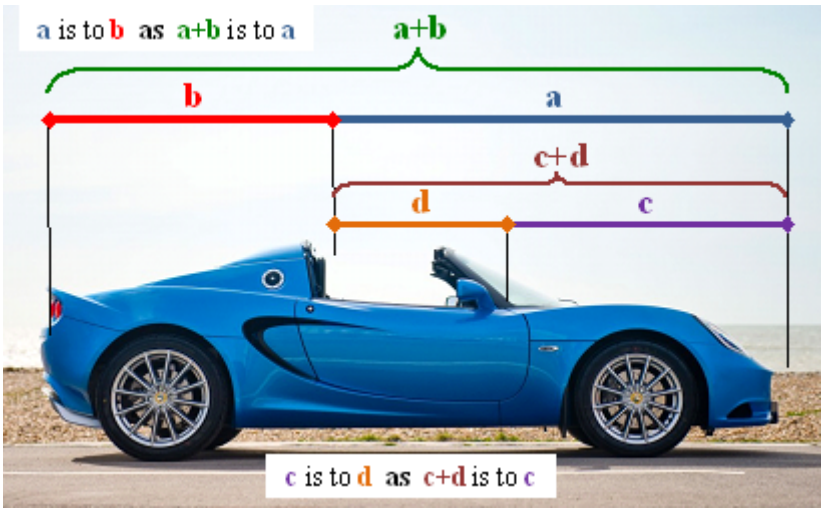


Figure 11. Lotus Elise and golden section

Ancient scientists determined beauty according to the proportion of the human body, i.e. the golden section, in which the ratio of shorter and longer parts corresponds with that of the longer part and the whole. An object built on principles like that makes the viewer feel the lasting beauty and reliability due to its natural proportion. The proportions of the body of the *Lotus Elise* sports car built on the basis of golden section are shown in *Figure 11*.

Another basic element appearing in nature and engineering practice is the hexagon. As these two-dimensional figures can be put next to each other optimally without any dead

space, the length of walls surrounding the cells projected to the area unit can be minimized alongside with maximizing the usage of space on a flat surface. Therefore, the honeycomb structure in the case of bees and wasps perfectly exemplifies the intention for the principle of minimum material and energy in the living world. The other advantage of this kind of construction is the structure, which is rigid despite the thin walls – and this is one of the most important conditions of engineering tasks (*Figure 12*).



Figure 12. Hexagonal alveole structure

8. CONCLUSIONS

Although it falls into oblivion, mankind has spent much more time close to nature than far away from it. Despite new impulses, social effects or changed behaviour patterns earlier experience gained by our ancestors instinctly come up to the surface. In the subjective science of design it is worth finding stable guidelines that are related to these associations of ideas coded in our mind. This way we can develop products with design accepted more and more widely.

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