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A Glimpse to the Theory of Design Naturally: A New Approach to the Theory of Form in Industrial Design

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Abstract: Our eyes look out on a complex world, but the brain unconsciously selects what interests us and makes it seem simple [41]. These interests are strongly dominated by the long tradition of geometric and reductionist approach to the world and nature [3]. Designers usually reduce natural complex forms to their basic geometries and change them to manipulated and adapted materials for their designs. It is believed that this common vision to the nature deprives us from perceiving its complex reality [40]. Meanwhile, appealing to the complexity is a key tool for renewing the normative aesthetic language and seeking freedom from conventions in field of design [1]. Based on this argumentation a phenomenological study was being conducted to learn from the nature's complex approach to the form issue in order to achieve possible renewal solutions. Numbers of natural phenomena were chosen and obsessively studied. Investigations showed that the nature's real approach to the theory of form is basically different from designers' approach. The theory of Design Naturally (TDN) is generated based on nature's different approach to the form issue. Present paper is aimed to concisely introduce different ideological paradigms of this theory. Out hypothesis is that it provides a new aesthetic language to challenge the aesthetic conventions established in industrial design culture.

Key-Words: Aesthetics, Abstraction, Complexity, Theory of form, Natural forms, Industrial Design, Forces

1 Introduction

Human's perception from the world is obedient to his mind (Nasr, 1996) and his mind is obedient to platonic forms and metric proportions (Lorand, 2000; Rotzler, 1977, Alexander, 2002). This statement shows how he can be prevent from seeing and understanding the complexity of world and the way it is shaped (Wrathall, 2005). Being obedient to these presupposes and mental patterns, consciously or even unconsciously, have had obvious effects on different aspects of human life. It is also manifested in the world of design in format of geometric forms and abstraction. Considering unstable definition of the beauty and emerging need for renewing the aesthetic language (Akner-Koler, 2007), this study is aimed to propose a new vision to the forms and the form-giving process, based on the nature's logic about

this issue. This study has been conducted by ignoring the traditional aesthetic presupposes and geometric aesthetic reasoning in order to get closer to the complex reality of forms in nature and see what is usually ignored, omitted or diluted through the observations (Kamehkhosh *et al.*, 2010).

Phenomenology is a compatible conceptual framework to explain the approach of this study. Phenomenology is about studying phenomenon based on direct and pure experience and observing the world by ignoring presupposes (Verneaux and Wahl, 2009). As phenomenology question presupposes in order to study the reality of things, we are also questioning the aesthetic norms and conventions to get closer to the reality of forms in nature. From this point of view, this vision is comparable with what Lakoff and Johnson (1999) refer to as the *basic-level experience*. An experience which is not governed by conventions or cultural interpretations and deals with what we sense as real to us (Akner-koler, 2007, 26). This kind of vision opens designers' eyes to the ignored qualities of natural forms such as complexity, irregularity, asymmetry, etc. the qualities which are known as key tools for renewing the aesthetic language and seeking freedom from conventions in field of design (Akner-koler, 2007; Bois and Krauss, 1997). Considering these almost untouched qualities, based on the nature's logic in creating forms, would surly provide designers with the huge amount of theoretical and practical creative possibilities in industrial design culture.

1.1 Quantitative approach

Rationalism and humanism of renaissance enabled a scientific revolution, which let scholars look at the world in a different view and by reason & ration. In the 16th and 17th centuries, in contrast with medieval centuries, knowledge was strongly based on rational calculus, mathematics and quantitative measurements (Bertelsen, 2004; Nasr, 1996).

Galileo, in his famous phrase under the title of "*IL Saggiatore*" likened the nature to a math book with geometric shapes as its letters. He believed that this book could be merely understood by human's rational mind (Nasr, 1996). Descartes' mathematical definitions of time, place and substance, has had the deepest affects on the essence of the modern science structures. His reductionism went to extreme until he defined nature as a physical moving reality, which is merely understandable via geometry and quantitative measurements. In his analytical geometry everything in the world was synthetically constructed of the simplest rationally conceivable basic elements: numbers (Bürdek, 2005).

Scientific revolution reached its zenith by Newton, who in his essay called Principia certainly declared the beginning of the quantitative and mathematical approach to the nature (Frangmyre et al., 1990). Newton's mathematical principles of natural philosophy stood as a classical prototype, or canon, by which to judge all subsequent sciences.

Through the efforts of some individuals such as Christian Wolff, mathematical and quantitative methods were gradually developed in other fields of science too. In fact scientists were strongly motivated to impose order on all domains of nature via quantizing and reducing its complexity. *L'esprit Geometrique* (geometric spirit) is the French expression for this extensive approach which were shadowing on all European scientific activities of 18th century and also affected many aspects of the western culture up to 20th century (Nasr, 1996). Industrial revolution in 18th century and modern technology stimulated the penetration of

quantitative attitude to different layers of human life (Nasr, 1997), such as Art and design. Since then, Geometric and mathematical principles have been interpreted by object makers in search of form, when their application to the standardization of components and reliable mass-manufacturing methods made precision work achievable on a commercial scale.

1.2 Modernistic approach

Sami azar (2009) refers to Immanuel Kant as the first real modernist, because he introduced the idea of self-criticism. The idea which later turned to the substance of modernism and its aim was to crystallize the pure form of art. This purity interpreted as an internal and structural look to the art itself and exclusion of any content form it. In this context, issues such as the process of conception and representation, form, composition, color, line, etc. became the major concerns for artists and thus, modern art inclined to abstraction and geometry for better self analysis and self-investigation (Lucie-smith, 1997; Sami azar, 2009). Clement Greenberg in his critic theory considered *abstraction* as a tool to ensure the aesthetic quality of the modernism, an abstraction which is devoiced of any reality (Archer, 2002, p.44).

On the other side, the aspects of the modern art movements such as De Stijl, Purism, and Russian constructivism as the major artistic roots of industrial design were to turn toward *science* for concepts and models (Akner-Koler, 2007; Heskett, 1993). Heskett (1993) declares that these attitudes were based on the Influence of Idealist philosophical traditions, and the search for Platonic ideal forms. Therefore, the quantitative approach of *science* appeared toward abstraction and in particular, geometric forms in modern world of art and *design*. For instance, reductionist-mechanical aesthetic of De Stijl which was characterized by simple geometric elements created enduring design categories, some of which are still valid today (Bürdek, 2005).

As the flagship for the subsequent development of design, Bauhaus, have had a strong formative influence in 20th century. It was a theoretical center of modernism, (Sami azar, 2009), and its successors such as the Ulm school of design and the new Bauhaus, also followed its tradition especially in their foundation courses.

The Ulm Approach to design education was also strongly based on rationality, strict form and construction. Only the "exact" natural sciences were truly accepted as reference disciplines. Besides, Mathematical disciplines with possible applications in design were also respected. The Ulm principles spread quickly and applied in an exemplary industrial context in 1960's (Bürdek, 2005).

Akner Koler (2006) in her postmodern criticism in an article, "Expanding the Boundaries of Form Theory", refers to the aesthetic approach of modernism and confirms that the normative aesthetic language entails a renewal.

> *"Since the fall of high modernism in the 1960s there has been little effort from the art and design community to renew or replace the modernist aesthetical language. Hal Foster refers to this period as "non-aesthetical paradigm". Post-modern criticism points to the limitations of the modernist discourse with its aspiration of defining universal principles, genotypes and the search for "pure form". This search for pure form created an elite attitude aimed to define criteria for "good" design, thereby excluding deviations from a "norm" and discriminating against alternative individual expressions".*

Although post-modernism criticized limitations of the modernism, still frankness and simplicity of modernism and its abstract expression was

traceable in post-modern approach (Archer, 2002, p.159).

In fact modernism is a continual matter and changing foundation which has had an almost clear birth time but no definite declination. We have never passed it and won't pass too. The light of modernism has been thrown on many domains of our life (Sami azar, 2009). Modernism as Habermas writes seems: "dominant but dead" (Halfoster, 1983).Today, the aesthetic contributions of modernistic movements has become the dominant aesthetic norms and they still dictate the conditions for beauty, at least for design and architecture (Akner-Koler, 2007).

1.3 Deprivation from reality

According to the strong and deep-rooted culture of geometry it can be concluded that this reductive approach has also affected designers' visions to the forms in *nature*. From a phenomenological point of view, it can be said that the aesthetic *norms* have formed some presupposes in designers' minds, which made them unable to see the reality of forms in nature before their mind could perceive it by abstraction. In fact, Designers usually reduce complex forms to their basic geometries and proportions, in order to ordinate complexity and harmonize it with their design paradigms (Kamehkhosh, *et al.*, 2010). The function of presupposes in human's mind is similar to the function of a red filter, which makes only a special wave length visible (Gleick, 1988). In fact, the filtering mind expect to see geometric forms and patterns in nature and therefore reduces real complex quality of forms to simple geometric patterns and proportions (Whyte, 1968) in order to understand and bring it under the conscious control.

This argumentation has many parallels with Christopher Alexander's criticism on human's mechanical and rational picture of the world in his 2002 book of "The Nature of Order". He claims that all aspects of our activities are dominated and affected by our picture of the world; meanwhile we may not even know that we have a specific one. In his point of view the modern human, can definitely trace the footprints of an inherently mechanical, rational and mathematical picture of the world inside him. This picture has penetrated deep inside and has affected his vision to the world and nature, his morality and even his aesthetic reasoning's. Alexander's declares that this approach releases just mechanical aspects of an order, which would not be the whole reality for sure, and thus deprives us from perceiving some other essentials.

According to George Berkeley, the quantitative approach to the nature, abstracts its reality and presents just an aspect, which is in our mind (Nasr, 1996, Alexander, 2002). Martin Heidegger explains that human usually escapes from complexities and irregularities of universe. Reduction of the infinite universe to understandable structures and models is equal to limiting the world to our limited language. Besides, taking this simplified model of reality as the reality itself would surely deprive us from perceiving the reality of universe as the way it is and so would waste away its real values, he declared (Wrathall, 2005).

Based on the same logic, use of geometry entails a reductionism that excludes and "washes away" contact with the real world (Akner-Koler, 2007). Abstracting natural forms in order to simplify their complexity prevents us from perceiving their reality. In other words, geometric approach to the forms in nature deprives designers from seeing and perceiving many complex aesthetic values of natural forms.

1.4 Design and Nature

In addition to what was said about the human common picture of the world, and its effects on his perceptions from nature, the way he represents his perceptions from nature is also an important criterions by which the human inspirations can be discussed.

Since Descartes, man experiences himself as the ego that relates itself to the world by positing the world at its disposal. He posits the world opposite himself as his object (Nasr, 1996). As Papanek (1995) states, much of the modernism theory was based on confrontation with nature and so bringing the nature under the control has been the motivation of human activities. For Michel Serres (1997), representation is an operation that reduces the complex real to rational and controllable consequences. In the context of art, representation has also been applies to control the power of nature (Gardner, 2006). In modern approach, geometry and abstraction, for their organizing and simplifying capacities, have almost always been two inseparable essentials of the representation process (Sami azar, 2009).

Therefore the nature inspired forms can be categorized according to their degrees of abstraction. The more designer abstract natural forms, the less the original properties such as asymmetry, irregularity, chaos and complexity would last (Kamehkhosh et al., 2010).

At the lowest and therefore the most abstract level, there would be the mathematical proportions, golden ratios and numbers. György Doczi in his 1981 book of "The power of Limits" does an extensive research on the proportional harmonics in nature, art and architecture. His abstract approach, achieve mathematics behind nature and the golden ratios. He talks about the forms of natural phenomena with numbers, patterns and pure geometric proportions and then shows how many of arts and designs have been inspired by these golden ratios and pattern of natural phenomena. In 1960s, Architect Werner Nehls, stated that rational and functionalist understanding of design is completely outdated. He said it is now time to replace the masculine, colorless, geometric or objective forms with emotional, irrational and feminine approach to design with contrasting colors and *organic* forms (Bürdek, 2005). Designer Luigi Colani brought these thoughts in to practice by applying organic-dynamic design principles; he called them Bio-forms (Bangert, 2004) and achieved a higher level of nature inspired forms in product design.

Colnai and his successors' tendency toward specific inspired types of forms, which are characterized with smooth, curved surfaces and circular shapes, later turned to one of the misinterpretations in aesthetic culture of industrial design; the way, that these forms have become known as the symbolic and normative expression of the forms which are inspired by the natural references (natural forms). So that both, the form of the natural living organisms and the curved, circular and fluid forms, are usually named with one phrase of "organic forms"; and The phrase "the nature inspired forms" almost always recalls smooth, curved surfaces, circular shapes or in some cases specific geometric patterns in mind. Even in dictionaries one of the definitions of the word "natural" is: not sharpened or flatted, having no sharps or flat (Procter, 1978).

Organic form, the forms of the living organisms, as Waddington explains, would be conceive as "*something which is produced by the interaction of numerous forces which are balanced against one another in a near-equilibrium that has the character not of a precisely definable pattern but rather of a slightly fluid one, a rhythm…"* (Whyte, 1968).

According to the influence of man's intellectualizing and pattern-making habit of simplification, it is expectable that human's work of art (and design) would be a diluted and abstracted version of the reality which has lost its unresolved complexity (Whyte, 1968). John Dewey (2005) in his book of Art as experience declares that "abstraction" occurs on the basis of passion and purpose, and the "choice" occurs as the result of these factors. Accordingly, organic approach, as a style, can be defined as just a level of abstracted natural forms (Kamehkhosh *et al*., 2010) and just a choice, which has been taken as the result of a specific passion and attitudes to curves, and fluid forms and some technical manufacturing purposes (Bangert, 2004).

This misconception becomes more acute when designers *consider* their inspirations (diluted curved and fluid forms) equal with natural form references. Because, they are in fact equalizing a model or an aspect of reality with the reality itself, which as Heidegger showed, this will deprive them from perceiving the reality itself (Warthall, 2005). On the other side, when this misconception turns to a costume or habit, eyes would become apathetic about the other choices (Dewey, 2005). This is one of the norm and conventions the theory of design naturally has tried to be discouraged from.

The language used to bring this theory up is strongly inspired by Professor Rowena Reed (and her husband Alexander Kostellow). The efforts of these prominent artist/teachers have created a comprehensive educational program in the structure of applied aesthetic and visual relationship (Greet, 2002).

"Uniting geometric and organic aesthetic reasoning" is the major contribution of Professor Reed to the applied aesthetic (Akner-Koler, 2007) Reed and Kostellow's vision of merging geometry with organic principles of growth and tension is one of the basic clues which my studies find its roots in. Reed and Kostellow deconstructed visual abstraction from geometry into forms, movements, and relationships in order to integrate them with organic principles of growth, movement, tension, gesture, asymmetrical composition, etc (Greet, 2002). Alexander Archipenko is the one who influenced Rowena Reed in her vision. Archipenko's work with both Geometric abstraction of the figure and studies of convexities and concavities appeared in Rowena Reed's visual abstraction exercises which starts with combination of rectilinear volumes and pass the road of complexity to the exercises of convexity, concavity and organic spaces (Akner-Koler, 2007, Greet, 2002).

Cheryl Akner-Koler's contributions to the field of applied aesthetic and her new ideas about organic reasoning and formlessness have also been extremely valuable and inspiring through the generation of this theory.

She introduces a model of "Evolution of Form". This Model "has a 7-stage horizontal axis that "reciprocally interlaces geometrical law-bound reasoning with organic principles". The stages are join, intersection, divide, adapt, merge, distort and organic which shows the evolution progress of form through increasing complexity. Besides, each of the stages has a vertical axis with a bipolar spectrum. The bipolar concept introduces the positive and negative extremes of each of the stages. It gives equal weight to activities that buildup and break down the geometric structure (Akner-Koler, 2007). The Idea of bipolar spectrum is a smart opening to the world of complexity (Fig.3). For example, the stage of distort brings the quality of "deform", which is almost often known as destruction or ugliness, in to categorization and the boundaries of aesthetic reasoning.

The negative pole (-) of the distort stage of the EoF model, deform, is what we call it reality (+) in nature when we look through the glass of the theory of Design Naturally (See section 4.5 Form). This is where the theory of design naturally meets the EoF model. Giving the positive value to the commonly ignored (-) qualities is the first contribution of the theory of design naturally to applied aesthetics.

This Study can be considered in line with the efforts of Akner Koler in term of developing constructive and critical methods and models that challenge normative trends in design aesthetics. The major point of departure is that the theory of design naturally is based on ignoring the geometric references. It enables designers to think and dialogue complex about complexity (Kamehkhosh, *et al*., 2010). Besides, this theory promotes complex qualities of forms and discourages designers from their modernistic tendencies. Furthermore, final point is that this theory provides applicable solutions in order to connect the theory to real design practices.

2 Aims & hypothesis

This paper aims to:

- Throw a new light on the issue of forms in nature, by taking a non-geometrical and more realistic approach to the forms in nature and by forgetting the normative conventions in industrial design culture, in order to achieve a new theory of form.
- Introduce some analytical and practical tools and a methodology, which connect the theory to real design practices.

Our hypothesis is that this approach would help designers to think about different paradigms of form and the form-giving process in a new way and based on the natures' approach to the form issue. Moreover this approach could provide designers a new holistic aesthetic language, which fertile the ground to go beyond the law-bounded principles of geometry and aesthetic norms in industrial design.

3 Methods

Goethe's vision to the nature has been inspiring for this observation. He ruled mathematics out of place in natural history. When he sees in snail, or nautilus, or tiny foraminifera or radiolarian shell a close approach to sphere or spiral, he is prone of old habit to believe that after all it is something more than a spiral or a sphere, and that in this "something more" there lies what neither mathematics nor physics can explain (Thompson, 1945, 3).

According to the aforementioned aims and in order to find out nature's real complex approach to the form issue, a case study was performed. Geometric reductionism, aesthetic norms, interests and presupposes were avoided and it was tried to see the forms in nature in the way they really are. Nothing was allowed to be omitted or diluted. Every little detail, observable with naked eyes, was considered as an intentionally created and designed element of forms.

To achieve reliable and comprehensive results, the target group was consisted of several types of natural creatures such as birds, reptiles, fish and plants. The study started by observation and realistic drawings. In the first phase, 100 types of animals and plants were observed. The materials for observation were pictures, movies and also virtual observations. Some of the pictures were selected from websites and books, while others were taken by digital camera.

Samples were carefully studied and detailed descriptive notes and realistic analytical drawings were provided. This Study investigated gestalt of the forms and the followings points:

- The quality of each of the elements of form such as line, surface, volume, texture and color.
- The composition of the elements
- The relationships of the elements with each other and with the whole composition
- The growth process

According to the defined paradigms of observation, it was apparently understood that nature's approach to the issue of form and its aspects has a different account with the normative approaches in industrial design culture. Therefore, in the next step we focused to find out if any general logic could be recognized to describe the differences, the complex compositions, relations, visual characteristics and procedures.

The written notes reviewed and a library research was performed regarding the scientific aspects of form and the form generation processes in nature. Through this phase we achieved two major descriptive statements which could generally and designerily explain the form generation manner and the complex qualities of natural forms (See sections 4.5 Form & 4.7 Complexity).

Reviewing and adjusting the detailed descriptive notes of the visual characteristics, we could realize 14 major constant characteristics that were common in almost all the observed samples. Our hypothesis was that these characteristics may show the common approach of the nature to different elements of form. In this regard, statistical analysis performed and finally confirmed this hypothesis (See section 4.9 Visual Abstractions). An interesting point is that these items showed how the nature's aesthetic vision is different from the designers' vision. The scope of this paper does not offer the opportunity to explain each of these 14 principles separately and in any depth, therefore details of the statistical studies have been also excluded here.

Observations showed that the final forms in nature strongly depend on the process in which they have been grown. Therefore, it was tried to see if it is possible to get any appropriate idea for designers from the growth process in nature. The result was a new method which could symbolize the growth process in the industrial design context. This idea, as a complementary tool, could connect the theoretical findings to design practice and also granted an educational value to this theory (See section 4.6 Form-giving).

In total, our understandings as industrial designers from studying natural forms could provide a comprehensive new vision to aspects of the form issue. These findings are presented as the theory of Design Naturally for industrial designers. This is an applicable theory with clear picture of the nature, aesthetics, form-giving process, complexity, abstraction, geometry, gestalt, form, visual abstractions and function. Our hypothesis is that this theory could provide designers a new holistic aesthetic language, which fertile the ground to go beyond the law-bounded principles of geometry and aesthetic norms in industrial design.

4 Results

The ideological approach of the theory of design naturally to the major paradigms of the *theory of form* is generally introduced and discussed in the following.

4.1 Nature and naturally

Nature and the human picture of the world (nature) are two of the major issues which the ideas of this paper have been built on. As it has been mentioned in the introduction, this theory is based on an anti-modernistic approach to the

world and nature. Development of this theory was the result of forgetting the common modernistic reductive approaches, norms and presupposes about the nature, natural forms and getting inspiration from it. Therefore, understanding this theory would also entail a fundamental revision in the user's picture of these eras.

This would be a big misunderstanding if we consider the theory of Design Naturally in the same category in which the other nature based approaches such as bionic design or organic design have been placed. In addition to the fundamental difference of this theory with the others in its picture of the nature and its way of observing natural forms, there is one other major point of departure too.

In spite of the other approaches which look through a specific creature(s) in nature for mechanical or formal ideas and for receiving inspiration from (Trotto and Cianfanelli, 2006), the theory of Design naturally, does not offer designer some tools to study natural phenomena to get inspired by, but, this theory, itself, is the result of studying the nature with the aim of understanding its general complex manner of creating forms. In other words, this theory is an effort to understand the nature's way of thinking about the aspects of form and to present it in a designerily way for industrial designers.

Therefore the users of this theory would not refer to any specific natural phenomenon for receiving inspirations from, but they are provided with a design package consisted of clarified ideological paradigms about aspects of form, analytical and practical tools and procedures to be able to think and design the way nature does (to Design Naturally).

In this regard, the adjective "Natural" and the adverb "Naturally" become more important than the word "Nature".

The word "Natural" means: being in accordance with or determined by nature, having a specified character by nature, growing without human care, not produced or changed artificially, Not altered, treated, or disguised. The word "Naturally" means: in a natural manner, by natural character or ability, according to the usual course of things, without artificial aids (Procter, 1978).

The theory of design naturally is searching for the aesthetic renewal solutions in these concepts. And thus phenomenological study of nature as a criterion by which "natural" and "naturally" could be defined would be vital.

4.2 Aesthetics

The aesthetic vision of the theory of Design Naturally to the nature in comparison to the normative positioning of the former approaches, can be symbolized as the position of the *everyday aesthetics* (Saito, 2007) in relation to transcendental approach to aesthetics in the wake of Immanuel Kant who "concentrates narrowly on intellectualized properties of from" (Shusterman, 2000, 8) and emphasized the unique character of art. This comparison clarifies this theory's properties for aesthetic reasoning and aesthetic judgment. It shows how the common borders between beauty and ugliness can be challenged.

Any sensible (observable) thing can be the subject of aesthetics (Saito, 2007). This statement would be instrumental, when the filtering, limitative and eliminative layers of Geometric reductionism, aesthetic norms, interests, prejudges, habits, and presupposes fade away from the sight (mind), as much as possible; because, habits and fondness, would cover the eyes and make them apathetic about reality (Dewey, 2005). Saito's statement in practice, conditional to comply with this quality of observation and in terms of observing forms

in nature, would cause two positive results. Firstly it would turn the focus from just those phenomena which are known as aesthetically compelling ones (analytical aesthetics in nature) to *every* observable phenomenon such as swaps or worm-eaten carcasses. Secondly it would help to observe more of commonly ignored complex details and so more of reality in phenomena. It would help to get closer and relies more on what the eyes see.

The Theory of Design Naturally does not offer a canon of principles that determine what is beautiful and what is ugly. According to the prophecy of this theory to challenge the normative boundaries of modernistic pure aesthetics and geometry, it gives priority to reality as it can be observed. Our studies showed that this reality is interlaced with such visual qualities as complexity and ugliness. It is believed that this approach would widen designer's aesthetic possibilities and change the normative paradigms of aesthetic judgments.

4.3 Abstraction

In the words of Whitehead, when we think about a substance, place or a quality, we are actually presenting a simplified version of reality to ourselves, which is a high degree of abstraction itself (Nasr, 1997). Therefore it is believed that abstraction is unavoidable.

The concept of abstraction simply means the act of extracting the essential qualities in a thing, a series of things or a situation (Hale, 1993). But as it is mentioned before, the passion and the purposes which choose the "essential qualities" of abstraction (Dewey, 2005) are strongly dominated by human's rational-mechanical picture of the world (Alexander, 2002).

The Theory of Design Naturally has been generated based on such quality of observation which ignores the common modernistic and reductive-geometric based approaches to the world and nature. Although in this we accept an unavoidable process of abstraction, it is tried to reach more realistic picture of the complex quality of natural forms by ignoring any passion or interest to any especial type of forms in nature, that cause in an unconscious abstraction, during the studies to generate this theory.

The main contribution of the theory of Design Naturally to the issue of abstraction is to reverse the common, one way road of complexity to abstraction to the growth process of abstraction to complexity (See section 4.6 Form-giving).

4.4 Geometry

Although the Theory of Design Naturally confirms the analyzing capacity of geometric reasoning (Akner-koler, 2007; Alexander, 2002; Rotzler, 1977), according to the aims, it would be tried that the geometric reasoning does not have apparent manifestation in final forms and does not dictates pure geometric solutions (Kamehkhosh *et al.*, 2010).

In our point of view Geometry is an analyzing and organizing tool which should be applied just in a right place. Otherwise, it would have negative effects on the creative thinking through the form-giving process.

4.5 Form

Form refers to the shapes of material objects (Whyte, 1968). Here we are dealing with the subjective conception of form. The theory of Design Naturally introduces a descriptive statement which explains how complexity, as the major characteristic of natural forms appears. Hereby, complexity is aimed to be grasped as the way it is and in a designerily way.

"Form Follows Natural Interaction of Forces", this phrase shows our understanding about how forms appear in nature. Our point here is that this phrase FFNIF can simply and generally explain some qualities of forms in nature such

as, chaos, asymmetry, unpredictability, etc. for designers (Kamehkhosh *et al.*, 2010). We believe that taking this way of thinking about complexity in product design would enable designers to bring them in to the world of products in a logical manner.

The word "Force" refers to two types of energies: Directional (Akner-koler, 2007; Alexander, 2002, Greet, 2002, Thompson, 1945) and Surrounding (Fig.1).

In his classic 1917 book on Growth and Form, D'Arcy Thompson analyzed biological forms in terms of physical forces. He states that Force is energy in its various forms and has no independent objective existence. It is an appropriate term for explaining the causes by which the forms and changes of form are brought about. Therefore the word force as a subjective and symbolic concept would be applied for the" magnitude and the direction of an action" upon the form (Thompson, 1945, 16).

Directional forces refer to the energies acting upon the movement of the inner & spatial axis of form and its elements. These forces increase the complexity and asymmetry in forms by affecting the surfaces from beneath and above and with different angles and intensities. The pressure or the tension of the force is absorbed by the positive element and then projected outward through the form and into space (Akner-Koler, 2007). For instance they may cause curves, bends, concavity, convexity or wrinkles in the form.

As a complement to directional forces, we defined the second type of energies called surrounding force. Each element of forms in nature is surrounded by a type of energy, which can affect the form of its adjacent elements. To some extent, these arrangements are comparable with invisible magnetic field, which affects the iron particles, around it.

Interaction of the forces refers to the multi directional relationship of the energies that act upon and shape the form. As Dewey (2005) declares, form appears when equilibrium is achieved through the harmonious dynamic relations and interaction of energies.

The quality of this interaction between forces is defined by the word "Natural" which is the keyword and the departure point here. It refers to a basic character of a thing, which is concerned with nature and has ordinarily happened in the world with no human control (Procter, 1978).

Figure 1. Directional forces (a), surrounding forces (b) acting upon a cylinder, Photo: Parsa Kamehkhosh

To go beyond the main points, the phrase Natural Interaction of Forces is pointing to "What ordinarily happens by multi-directional relationship of directional & surrounding energies affecting axis and constituting parts of form". It is referring to the basic characteristics of what appears by the interaction of forces during the growth process (Kamehkhosh, *et al.*, 2010). As an example, note the complex, irregular, chaotic forms of the mountains. Uneven nesses on the earth and mountains can be considered as what naturally have happened as the results of interaction of the forces from the colliding piece of the earth (fig.2).

Figure 2. Mountains,
Photo: wikipedia.org/Tatra_mountains_western

Not just natural phenomenon but irregular and complex qualities in forms of other phenomena can be explain by this statement too. For instance think of a crumpled piece of paper, which is the natural result of interaction of the forces applied by fingers to it and the result is complexity, irregularity, asymmetry.

The concept of "Deform" which just mentioned az the negetive pole of the distortion stage in EoF model (Fig.3), is also a good exampl of this statement. Two forces contract a cylinder by asymmetrically pressing against the two base surfaces of it, and the natural result of this interaction is a complex, irregular form.

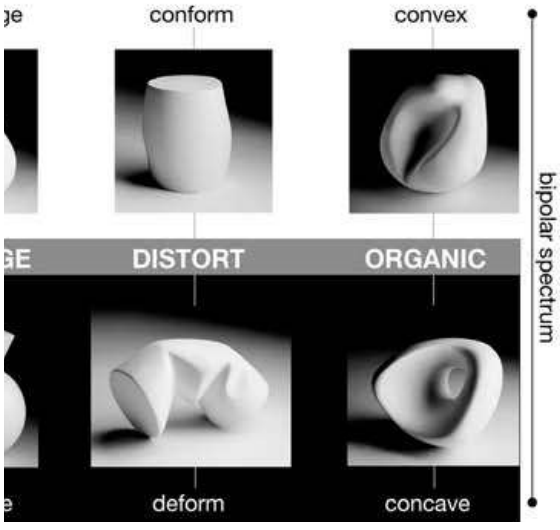

Figure 3. Two final stages of the Evolution of Form-model (cropped), Photo: Akner-koler

This statement is both an analytical and a practical tool which by designer would be able to talk about reasons behind the complex qualities of forms and organize their thoughs durring the form-giving process.

4.6 Form-giving

Not only the final form but the procedure through which the final form evolves and appears, is the subject of consideration in the theory of design naturally. According to Akner-Koler (2007), the form-giving process is a "conceptual and perceptual process in which the product gestalt develops into a physical form". It refers to the time period in which changes occurs in order to evolve; and time, as an organization of changes is growth, Dewey (2005) declared.

The approach of the theory of Design Naturally to the form giving process is basically inspired by the concept of *growth* in nature. As Waddington explains, absences of combined internal growth-forces in human artifacts make them different from natural phenomenon (Whyte, 1968). This notification leads us to the growth process. The growth process is actually a span, where forces would interact and carry out the gradual process of evolution until the final equilibrium is reached. Order and other aspects of form would not be imposed from outside and this is through the growth process which energies interact and interlock to achieve the final complex orders and coherent compositions (Dewey, 2005).

Christopher Alexander in his 1979 book of "The Timeless Way of Building" defines the "character of nature" as the central quality which is the "root criterion of life and spirit in a man, a town, a building or a wilderness". One of the properties of the character of nature as a complex organism is that it cannot be created directly and just should be grown indirectly. He

comes up with an example about a flower which cannot be constructed directly by human and the only way to have a flower is to grow it from a seed.

In our point of view Alexander's lessons, not only shows the importance of considering the growth concept in the creation process, but also teach us how to think naturally (Kamehkhosh *et al*., 2010), in order to let the character of nature flow into our design thinking. His emphasis on the word "indirect" is in fact referring to the essence of the concept "Natural". In this regard the "Form Follows Natural Interaction of Forces" is about letting the forces interact with no direct control on the results of this interaction. In other words, it means bringing the forces in to the context of interaction and leaving them free to affect and take effects from each other in their own inherent manner and through a growth process.

The theory of Design Naturally interlaces these thoughts with the form-giving process in industrial design culture. In this regard, it proposes a method under the title of *"Write the growth Story"* (WGS). The limitations of this paper do not allow going in to details but the general paradigms of this method worth to be mentioned here.

WGS method is designed based on this idea that designers should grow their forms from the birth stage to the final quality. The reference of this idea is the complexity theory and the statement of FFNIF which emphasis the interacting role of the constituting elements through the growth process for creating the coherent composition. The Common form giving processes do not consider this important issue and so the absence of what Alexander explained as the "character of nature" can be felt.

The WGS method provides designers a required time span to grow forms gradually and naturally. It is through this time span which the directional and surrounding forces of each of the elements acts upon each other and cause the dynamic changes of form. The manifestation of these interactions gradually appears, change and evolve until the final growth stage.

The other aspects of form such a function would gradually affect the form through the growth process too. They would have time to interlock step by step and reach higher level of integration through the process. Therefore the result would find a coherent quality.

4.7 Complexity

We don't want to understand complexity by finding models and extracting patterns or geometric orders. Instead it is tried to generate a designerily general definition about the logic of complexity; a definition, which helps designers to think about the complexity, as complexity. Being able to think and talk about complexity as it occurs in nature and in a designerily way is one of the most important objectives of this study; because it would strongly equip the aesthetic language, this theory is aimed to propose.

Accurate definitions are needed to prevent any misconception about the meaning of concepts of complex and complexity. Merriam Webster dictionary defines the word Complex, as "A whole made up of complicated or interrelated parts, a group of obviously related units of which the degree and nature of the relationship is imperfectly known". Neil Johnson (2007) describes complexity science as the study of the phenomena which emerge from a collection of interacting objects. Solé (2000) also defines complexity as a type of *order* that emerges from the interaction of many different components.

As it can be seen the role of constituting elements and their interrelationships are strongly bold in the definitions of *complexity* (Lindemann

et al., 2009). It gives interesting parallels to the contextual and subjective nature of the art and design process. Complexity theory has brought more attention to the interaction of parts and forces in a dynamic context (Akner-Koler, 2007).

For the theory of Design Naturally, complexity theory along with the FFNIF statement can effectively clarify the nature's complex approach to the form issue. Based on the theory of design naturally, the complex nature of natural forms appears as the result of the interrelation of constituting elements of form during the dynamic context of growth and life. The quality of these dynamic interrelationships can designerily be defined by the natural interaction of the directional and the surrounding forces which act upon the elements (FFNIF). This gradual process of evolution arrive complex *form*s when the final equilibrium is achieved.

Sometimes the concept of complexity is mistaken as the synonym of complicated and sometimes as the opposite of simplicity. Donald Norman in his 2011 book of living with complexity has considered these matters.

He declares that complexity is the state of world and this is the way things must be. But complicated is confusion, psychological state of person attempting to understand. He believes that understanding complexity require so much effort, not to reduce it to a models or patterns, but to understand the logic of the whole system. When the whole system is understood the enjoyable real simplicity appears. Therefore simplicity would not be the opposite of complexity. He concludes that "complexity is the fact of the world, whereas simplicity is in the mind" (Fig.4).

The theory of Design Naturally is not designed for creating complicated or confusing designs by learning from the complex approach of nature to create forms, but it is trying to understand the logic of the whole way of thinking. This would enable designers to inject the "character of nature" along with its complex qualities to the design culture. It is believed that this character would effectively be understood with our inherent conception of nature (Alexander, 1979) and cause a meaningful interaction between the products and users.

Figure 4. Complexity is the fact of the world, Leaf, Photo: gallery.hd.org/leaves

4.8 Gestalt

All elements of form play their role in relation to each other and to the whole. They interact in a dynamic context in order to achieve the final equilibrium. Directional and surrounding Forces act upon each other. Changes interlock and sustain one another (Dewey, 2005). The visual effects and the changes of these natural actions and interactions would last and develop and their consequences would be manifested in the final form.

The final result tells the story of growth process, the stages of evolution and the changes that have

been occurred during the process. Based on a Wertheimer's dynamic approach to gestalt theory, sense of gestalt would be experienced through direct and indirect perception of movements, forces and proportion in a complex coherent composition (Arnheim, 1997). The final form would be felt through meaningful relationships of the elements and also the coherent whole which reveals its growth history.

4.9 Visual Abstractions

Alexander Kostellow and Rowena Reed, who for the first time defined the industrial design courses in the US, believed that understanding the abstract visual order is the "heart of good design". They started the educational courses with the simplest and clearest elements of design and structure. These elements were line, plane, volume, value, texture and color. They believed that the first step would be investigation and experimentation through the functional capability of each of these elements (Greet, 2002). Bauhaus foundation programs and subsequently the Ulm school of design had the same approach too (Bürdek, 2005; Greet, 2002; Itten, 1975). This tradition still survives in more or less. The theory of Design Naturally has also followed the whole idea of this tradition in a non-geometric context.

As it was said before, few constant visual characteristics could be recognized in almost all the observed samples during the studies. Statistic analyses showed that these characteristics can be considered as the common visual approach of the nature in creating forms. The scope of this paper does not offer the opportunity to explain each of the statistic analyses and the principles separately and in any depth but as an introduction, the essence of these principles is discussed here.

Design Naturally principles clarify the nature's approach to different elements of form. Therefore, they have been categorized in to five groups of line, plane, volume, texture and color. Each group contains related principles, which explain how nature applies that specific element in different situations. These principles are not some dogmatic paradigms. They just provide some general remarks about each of the elements of forms which would have infinite varieties of manifestations in different situations.

Each of the principles is based on two major statements of FFNIF and the complexity theory. In other words they are the manifestations of these statements in natural forms and can be explained by the natural interaction of the forces in a dynamic context. These principles show that all constituting elements of form are exposed to the forces from each other and also affect each other multi-directionally through the evolution process of form to achieve coherent and unified final composition. The principles show the dynamic quality of the elements of form and their meaningful relationship with adjacent elements, their context and the whole composition.

The Dynamic Approach of the theory of Design Naturally to different elements of form and their relationships, would surly enters the concept of growth, tension and movement to the analytical language of this theory and this is where it finds parallels with Rowena Reeds approach to the structure of visual abstractions. She taught her students to think with their eyes. She talks about seeing and analyzing the subjective concepts of tension and movement of the elements of form via the direction forces of their imaginary axis and trying to achieve a beautiful balance in a final composition (Greet, 2002).

It should be noted that the theory of Design Naturally, according to what was said about the growth based form-giving process, propose such a more realistic approach to the concepts of movement, growth and tension. It works with

the real action of movement and tension of elements and their effects through the growth process and thus it would have more tangible manifestations in the final structure of composition.

4.10 Function

There is no recognizable priority of function or form in nature. High integration of form and function has made them inseparable. Dynamic growth process of forms in nature is the period through witch this integration appears and evolves. Similarly, Dewey (2005) explains the relationship between the form and matter. He declares that form and matter are inherently connected. This connection would appear and evolves gradually and nothing would be imposed to the form from outside.

It is expected to achieve this quality in products by applying the theory of design naturally and through the method it has considered to equip the form-giving process, inspired by the growth process of natural forms.

5 Conclusions

This paper is just an introduction to the theory of Design Naturally as a comprehensive design package which introduces a new approach to the aspects of the theory of form in industrial design culture.

The users of this design package are provided with a new aesthetic language equipped with different analytical and practical tool which enable them to bring the mentioned ideology in to the real design practices.

Not only this theory does not contradict designers' individuality but also, provide them with infinites creative possibilities to better express their individuality in a new aesthetic context. We believe that this theory could fertile the ground for many creative developments which can push the boundaries of geometry and traditional design aesthetics in industrial design culture.

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