*SEMANTIC PLAY AND POSSIBILITY*
*Invited Contribution*

# *Abstract Complexity Definition*

MARIUSZ STANOWSKI
*Independent (Poland)*

## Introduction

The complexity definition has appeared during my analysis of visual structures perception (Stanowski, 2005). The binary model of visual impacts finding was essential here for a possibility of the general (abstract) research. The Abstract Complexity Definition is one of the research results.

The difficulty of defining complexity is well characterized by Francis Heylighen (1999).

> Complexity has turned out to be very difficult to define. The dozens of definitions that have been offered all fall short in one respect or another, classifying something as complex which we intuitively would see as simple, or denying an obviously complex phenomenon the label of complexity. Moreover, these definitions are either only applicable to a very restricted domain, such as computer algorithms or genomes, or so vague as to be almost meaningless. Edmonds (1996) gives a good review of the different definitions and their shortcomings, concluding that complexity necessarily depends on the language that is used to model the system. Still, I believe there is a common, "objective" core in the different concepts of complexity. (Heylighen, 1999, p. 3)

## Binary Model of Visual Impacts

In my analyses I have been investigating the impact (the effects) of visual structures using examples characterized by various complexities (Stanowski, 2010).[1] Despite a great

[1] The analyses give information about the source field of exploration but they are not necessary for understanding the paper.

diversity of impacts analyzed in them, all of them conformed to the same principle of contrast. I looked for an example which could provide a representative model for these impacts. Such an example was found among the most simple and abstract structures, that is structures made up exclusively of two different types of elements, i.e., binary structures. Let me define more precisely the necessary meanings concerning a binary structure:

1. *Binary structure* (binary string) – sequence of 0's and 1's, e.g. 101101110011101101.
2. *Basic element* – each 0 or 1. There are 18 basic elements in the structure.
3. *Element* – distinctive basic element or group of basic elements e.g. 101101110011101101.
4. *Substructure* – distinctive group or arrangement of elements e.g. distinctive group of double elements: 101101110011101101, increasing arrangement of elements: 101101110011101101. In a particular case, when only one element has a particular feature, e.g. single: 1100100111000, we count it also as substructure.

What makes any substructure distinctive, is that all elements of the substructure have the same (common) feature. That is, elements which are double (e.g., 11 or 00) have the feature "double" or "doubleness"and belong to substructure "*double elements.*" Elements which consist of zeros (e.g., 0, 00, or 000) have the feature "zero" or, let say, "zeroness" and belong to substructure "*zero elements.*" For example: substructure "*double elements*" in the structure 101101110011101101 (below), contains all those elements which are "double," while substructure "*zero-elements*" in the same structure, contains all those elements which consist of only zeros. One may notice that element 00 belongs to both substructures because it has the features "double" and "zero." We can also say that the element 00 connects these two structures. For a better understanding, let's count all the substructures in the structure: 101101110011101101.

1. Single elements 101101110011101101
2. Double elements 101101110011101101
3. Triple elements 101101110011101101
4. Elements "0" 101101110011101101
5. Elements "1" 101101110011101101
6. Increasing arrangement in the first eight basic elements 101101110011101101
7. Decreasing arrangement in the last eight basic elements 101101110011101101
8. Symmetry of the structure 101101110 011101101

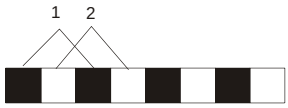
There are eight substructures in the structure. Notice that the number of substructures is the same as the number of features of the structure. Consider another example: we may count the substructures present in three binary structures (each with 8 basic elements) composed of black and white squares (Figure 1). Structure II has the

most substructures, i.e. as many as eight. This is due to this structure's having the greatest number of linkages, and arguably the optimal organization of elements.[2]

In structure I

1. black elements
2. white elements

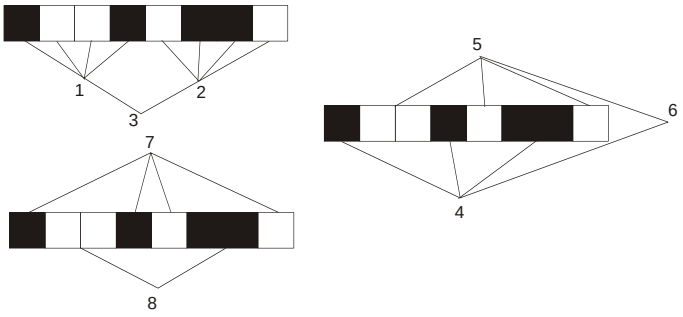
I.




II.

In structure II

1. symmetrical elements marked 1
2. symmetrical elements marked 2
3. 1 and 2 symmetrical to 3
4. black elements
5. white elements
6. 6. 5 and 4 show symmetry of black and white ones
7. single elements
8. double elements




In structure III

1. single elements
2. white elements
3. double elements
4. black elements
5. symmetry - two black ones and one white
6. same two elements

III.

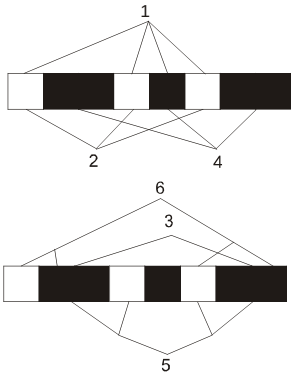



Figure 1. Counting substructures in three binary structures
(each with 8 basic elements) composed of black and white squares

[2] The method of counting substructures presented should be treated as merely an approximation because it fails to account for the degree of distinctiveness of particular arrangements. Nevertheless, it is sufficient for our purposes.

## Abstract Complexity Definition

By limiting the inquiry to the simplest abstract binary structures, it is possible to unambiguously determine the number of substructures within these structures. Once the number of substructures is known, it is possible to also specify the degree of complexity of the structure.

It is intuitively obvious that a structure which has more substructures but the same number of basic elements is a more complex one. As a measure of the degree of complexity, it is therefore possible to use the ratio of *the number of substructures of a given structure* to *the number of its basic elements.*

$$D = \frac{N}{n}$$

$D$ – degree of complexity of structure

$N$ – number of substructures of a given structure

$n$ – number of basic elements

According to Heylighen (1999), one of the important criteria of complexity is that "a system would be more complex if more parts could be distinguished, and if more connections between them existed" (p. 3).

The degree of complexity (D) relates to better organization (number of connections), while the number of substructures/parts (N) relates to the number of distinguished parts. Consequently, the complexity (C) of a structure would depend on the degree of complexity (D) and number of substructures (N).

$C$ – complexity of a structure $\quad C = \frac{N}{n}N = \frac{N^2}{n}$

I call the complexity (C) so defined (i.e., the product of the degree of complexity and the number of substructures/features), *Abstract Complexity*.

## How the definition relates to the existing complexity criteria

Returning to the Heylighen (1999) article:

> Let us go back to the original Latin word *complexus*, which signifies 'entwined', 'twisted together.' This may be interpreted in the following way: in order to have a complex you need two or more components, which are joined in such a way that it is difficult to separate them. Similarly, the *Oxford Dictionary* defines something as "complex" if it is "made of (usually several) closely connected parts". Here one finds the basic duality between parts which are at the same time *distinct* and *connected*. Intuitively then, a system would be more complex if more parts could be distinguished, and if more connections between them existed.
>
> More parts to be represented means more extensive models, which require more time to be searched or computed. Since the components of a complex cannot be separated without destroying it, the method of analysis or decomposition into independent modules cannot be used to develop or simplify such models. This implies that complex entities will be difficult to model, that eventual models will be difficult to use for prediction or control, and that problems will be difficult to solve. This accounts for the connotation of *difficult*, which the word "complex" has received in later periods.
>
> The aspects of distinction and connection determine two dimensions characterizing complexity. Distinction corresponds to variety, to heterogeneity, to the fact that different parts of the complex behave differently. Connection corresponds to constraint, to redundancy, to the fact that different parts are not independent, but that the knowledge of one part allows the determination of features of the other parts. Distinction leads in the limit to disorder, chaos or entropy, like in a gas, where the position of any gas molecule is completely independent of the position of the other molecules. Connection leads to order or negentropy, like in a perfect crystal, where the position of a molecule is completely determined by the positions of the neighbouring molecules to which it is bound. Complexity can only exist if both aspects are present: neither perfect disorder (which can be described statistically through the law of large numbers), nor perfect order (which can be described by traditional deterministic methods) are complex. It thus can be said that complexity is situated between order and disorder, or, using a recently fashionable expression, "on the edge of chaos". (Heylighen, 1999, p.3)

Let's consider the characteristics. What is suggested is that the parts/substructures distinction is in opposition to their connections or even exclude each other: quite independent gas molecules can't be completely bound crystal molecules in the same time. Only compromise "the edge of chaos" could be possible here. Our considerations deny such a reasoning.

In our analyses distinguished parts/substructures such as white elements, double elements, symmetry of elements etc., comprise also, what we can call, connections between them. Connection of elements is not in opposition to their distinction, but makes the distinction even stonger. Consider two elements which have common and different features. e.g. substructure of double elements connect different elements which have the common feature "doubleness. The common features attract those elements

making the different features of the contrasting elements stronger. Without connection different features wouldn't be even noticed.

In the example of structure II (Figure 1): substructure *"double elements"* connects substructure *"white elements"* and substructure *"black elements"* (directly double white and double black, and indirectly single white and single black); *"symmetrical elements marked 1"* connects substructures *"single black," "single white"* and *"double white,"* indirectly also substructure *"double black."*

It is also easy to see how components are "entwined" here, and how difficult is to separate them without destroying the structure.

One can also see duality between parts which are at the same time distinct and connected. Such duality is possible because each element belongs to more than one substructure (has more than one feature).

## Conclusion

The definition is not a speculative one. It is based on the model of visual impacts which is directly connected with nature of our perception.

The field of visual perception has been not explored yet enough, but it seems to be very useful and profitable for further analyzes, beside such fields as language, biology, society, physics.

## References

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## About the Author

Mariusz Stanowski was born in Warsaw, Poland, 1951 and graduated from the Technological University in Warsaw (1974) and Academy of Fine Arts in Warsaw (1979). He was Assistant Professor in the Academy of Fine Arts in Warsaw from 1979 to 1984 and since then has been a painter, theoretician of art, designer, and graphic artist. He is also interested in Theory of Information.
He can be contacted at stanowskimariusz@wp.pl. Website http://stanowski.artinfo.pl/