

<p>Alec Groysman</p>	<p>Abstraction in Art, Science, Technology and Engineering</p>
 <p>Topic: Art, Science and Technology</p> <p>Author:</p> <p>Alec Groysman</p> <p>ORT Braude College of Engineering, Karmiel, Israel http://www.wcjs.org/cv/groys/groys.html</p> <p>References:</p> <p>[1] Alec Groysman, "Corrosion for Everybody", Springer, Dordrecht, 2010, 368 p.</p> <p>[2] Tsion Avital, "Art versus nonart: Art out of mind", Cambridge University Press, New York, USA, 2003, 445 p.</p> <p>[3] V. M. Koshkin, "Senses and symbols", Folio, Kharkov, 2009, 184 p. (in Russian)</p>	<p>Abstract:</p> <p>The aim of this study is to elucidate why <i>abstraction</i> is used correctly in science and is misused in modern art. The origins, history and meanings of the term "<i>abstraction</i>" are discussed in this paper. This term is used in different contexts and meanings: Abstract idea, abstract number, abstract quantity, abstract noun, abstract picture ... Abstract art, abstract expressionism ... From concrete to abstract ... From abstract to concrete. The use of the term <i>abstraction</i> in the history of philosophy, science, mathematics, chemistry and figurative art is the same, but has different levels of abstraction. In all of these domains the meaning of abstraction is <u>simultaneous elimination and generalization</u>.</p> <p>We can read <i>abstract</i> as <i>generalization</i> or <i>overview</i> of any research at the beginning of any paper. Scientists use <i>abstraction</i> correctly in their formulas and descriptions of various phenomena and reactions. Technologists and engineers also use <i>abstraction</i> properly in various processes and mechanisms. Unfortunately, since the beginning of the 20th century artists and art theoreticians often misuse this term because they reduce abstraction to <u>simplification or elimination but without generalization</u>. Hence, they frequently use the term <i>abstraction</i> in cases where it is absent. This was related probably to the explosion of development and inventions in science and technology at the end of the 19th – beginning 20th century. People of art wanted to understand and to describe their relationship to achievements in science, technology, and as a result in life. We should not confuse <i>abstract</i> with undefined, indefinite, open-ended, indeterminate, fantasy or conditional. May we connect <i>abstract</i> with <i>absurd</i>? How is <i>abstraction</i> related to <i>unconsciousness</i>? Examples of use the term <i>abstraction</i> in art (painting, sculpture, music, and poetry), science, technology and engineering are given. The misuse of the terms abstract, abstraction, abstractionism in art is analyzed in this study.</p> <p>genlab@polimi.it Chair of GA conferences celestino.soddu@polimi.it</p>
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ABSTRACTION IN ART, SCIENCE AND TECHNOLOGY

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Premise. “*They want to show their education and always speak about incomprehensible things.*”

“*Они хотят свою образованность показать и всегда говорят о непонятном.*”
A. P. Chekhov (1860-1904), the Russian writer, the play “Wedding”.

The aim of this study is the description of the origin and history of the term ‘abstraction’, its meaning in science and art, and metamorphoses of its connotation in the 20th century.

The term ‘abstraction’ is used in different contexts and meanings: abstract idea, abstract number, abstract quantity, abstract noun, abstract picture ... abstract art, abstract expressionism ... From concrete to abstract ... From abstract to concrete... The use of the term ‘abstraction’ in the history of philosophy, science, mathematics, linguistics, and figurative art is the same, but has different levels of abstraction. In all of these domains the meaning of abstraction is simultaneous elimination and generalization. We can read this at the beginning of a paper: *abstract* as *generalization* of research. Scientists (e.g., mathematicians, physicists, and chemists) use ‘abstraction’ accordingly to its original meaning in their formulas and descriptions of various phenomena and reactions. Technologists and engineers also use ‘abstraction’ properly in creation of various processes and mechanisms. Since the beginning of the 20th century artists, art critics and art theoreticians often use the term ‘abstraction’ as a simplification or elimination but without generalization. Probably this happened because of the explosion of developments and inventions in science and technology at the end of the 19th – beginning of the 20th centuries. People of art wanted to understand and to describe their relationship to achievements in science, technology, and as a result in life. The change of meaning of the term ‘abstraction’ in art is analyzed in this study. Examples of use the term ‘*abstraction*’ in art, science and technology are given.

Keywords: *abstraction, art, science, technology, education.*

1. Overture

« *Art* is something that stimulates the individual’s thoughts, emotions, beliefs, or ideas through senses » [1].

Abstract idea, abstract thinking, abstract number, abstract quantity, abstract noun, abstract picture ... Abstract art, abstract expressionism ... From concrete to abstract ... From abstract to concrete ... One hears such combinations of words very often. The adjective ‘abstract’ stands before different words in their particular meaning. I remember well how our teachers in my school and then in the university in the

former USSR (Union of Soviet Socialist Republics) criticized abstractionism and abstract art in 1950-1970s. All this was alien to us.

Two events caused me to carry out this study. The first event was in 1989 when I visited Sofia, the capital of Bulgaria, at the conference on corrosion of metals. I took my boss from Moscow to the National Art Gallery in Sofia. When we entered the hall of abstract paintings he cried and was outraged by them. These pictures really expressed nothing, only forms, lines, shapes, spots, and sometimes different colors. It was by chance that it was a Bulgarian, Atanas Stoikov, who published a critical book of abstract art and its theory in 1964 [2]. The author dethroned the myth about 'abstract art' from the position of socialist realism and proved that this was not art at all.

I wanted to understand the paintings which expressed nothing. If these pictures are shown in museums, this means that there are people who like such pictures and can explain what this is, their meaning and value. My generation of 1960-1970s was educated on realism, namely, socialist realism – the official USSR art form. But Baroque and Renaissance paintings, classicism, romanticism, and impressionism were demonstrated in museums in Moscow, Leningrad and other cities in the former USSR. In any case, we were educated that any work of art must express some idea and reflect the real world.

The second event was in December 2011 during the 14th Generative Art conference in Rome, Italy. A young artist from Germany showed a picture and called it 'abstract' (Figure 1).



Figure 1. "1 to 2 to 3" 2011, (medium density fiberboard, a special wood material) and acrylic color [3]

In addition, the author compared his picture with abstract mathematical formulas [3]. We know well that mathematics is the most abstract science. I felt that the young artist put a different meaning of the term *abstract* than mathematicians. I decided to analyse what the term '*abstract*' means in art, science, technology, and engineering.

I was familiar with abstract paintings of Russian painters Wassily Kandinsky and Kazimir Malevich, the Dutch Piet Mondrian and Theo van Doesburg, the Frenchman Robert Delaunay, and the American Jackson Pollock. I liked some paintings by Kandinsky and Pollock (Figure 2), and did not like the pictures by Malevich, Mondrian and van Doesburg (Figure 3). For me, they expressed nothing. I explained my sympathy to paintings by Kandinsky and Pollock by aesthetics feelings: combination of colors and arrangement of forms, lines, particles, and different parts.

I understand that there are no quantitative criteria in art like in science. Our perception of works of art is based on the formula 'I like – I do not like'. In my opinion, any estimation of the work of art is subjective. But I wanted to understand why in any case there are people who enjoy a painting with very simple forms, lines and dots which are out of touch with reality. I feel that this probably depends on fantasy and the mood of a person.



Figure 2. **a** - *Composition VII* (1913) by Wassily Kandinsky; **b**- *Autumn Rhythm* (1950) by Jackson Pollock

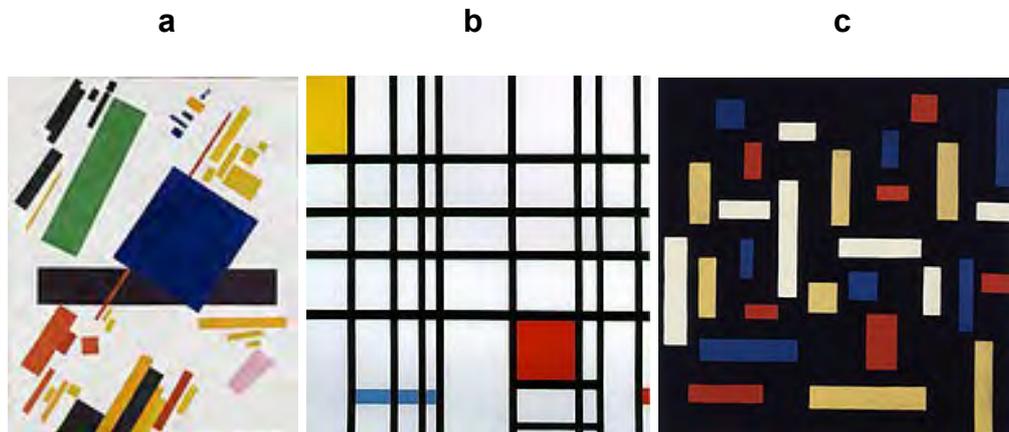


Figure 3. **a** – *Suprematist Composition* (1916) by Kazimir Malevich; **b** - *Composition with Yellow, Blue, and Red* (1937–1942) by Piet Mondrian; **c** - *Composition VII (the three graces)* (1917) by Theo van Doesburg

For instance, as in music when you listen for Bach`s fugue, Beethoven`s sonata or Chopin`s nocturne. This is called 'absolute (abstract) music' which is in contrast to the 'program music'. The latter reflects real picture or words. Listening to 'absolute (abstract) music', you may imagine anything that you want. This music does not reflect any actual word or world. Probably, like listening to 'absolute music' and enjoying the harmony of sounds, some people enjoy the harmony of colors, lines and forms by seeing 'abstract paintings' without any concrete particular picture in their brain ...

Analysis of literature showed that there is serious research on this subject [2, 4-6]. A profound analysis of *abstract art* is given by the Israeli philosopher Tsion Avital in his book "*Art Versus Nonart: Art Out of Mind*" where he consequentially and strongly proves on 61 pages that '*abstraction art*' of the 20th century is not '*abstract*' and is not '*art*' [4, pp. 167-228]. Why in spite of these profound works and books, people continue confusing terms concerning 'abstract' and its derivatives? In order to reply to this question, we should analyse the history of the origin and meaning of the term

'abstract'.

2. Definition of the term 'abstract'

Probably the first who introduced the idea of the process of abstraction in explaining the source of human knowledge was the Greek philosopher Aristotle (384-322 BC). He explained that human beings are born without any ideas in their minds. Man only knows through the process of abstraction of the essences of particular things and forming them into universal ideas [7]. For instance, all red things are similar in that there is the same universal, redness, in each thing. When we form the concept of a universal on Aristotle's theory, we 'abstract' from a many instances we come across. Aristotle used the Greek words *aphaeresis* (taking away from a thing, elimination, diminishing) and *korismos* (separation, dividing). We as it were mentally extract from each thing the quality that they all have in common. So how does the little girl get the concept of a human being? She learns to ignore the details, tall and short, black and white, long hair and short hair, male and female, etc.; and she pays attention to the thing that they all have in common, namely, humanity. In Aristotle's view, the universal humanity is the same in all humans (i.e., all humans have that exact same type in common); and this allows us to form a concept of humanity that applies to all humans.

Abstraction is a philosophical process by which people develop general concepts from experience. Abstraction is the process of *drawing out (elimination, separation)* the essence of things and giving them independent existence from the things of which they are inextricably connected. For instance, when we use the generic term animal we have merely extracted the essence of all animals (bear, dog, or wolf) and have made it to stand for the general idea of collectivity of animals.

In other words, *abstraction is a simultaneous elimination and generalization*. Let us open any scientific journal. Each article begins with an *abstract*, meaning *summary, synopsis, elimination, generalization, or quintessence*. Thus the noun 'abstract' is used for a summary, compendium or epitome of a larger work, the gist of which is given in a concentrated form [8]. *Abstraction is the opposite to concrete, detailed*.

Probably, the Roman scholar and philosopher Anicius Manlius Severinus Boethius (480 - 524 AD) was the first who translated the terms *aphaeresis* and *korismos* used by Aristotle (800 years later!) from the Greek into the Latin words *abstractio* and *abstrahere* [9]. These Latin words were adopted in other European languages. Did people use these terms during the next 15 centuries until the beginning of the 20th century? Nobody knows. These Latin words *abstractio* and *abstrahere* "have misled many, especially in the world of art, to think that abstraction is only separation." [4]

What happened in the 20th century? What is written about *abstraction* in different dictionaries and encyclopedias published in the 20th century? "Abstraction is a mental distraction from the object, its properties or signs, which really cannot exist separately by itself" [10, p. 9]. This was published in 1907 in Russia. This date is very important because the beginning of the modern abstract art is credited to Russian painters Wassily Kandinsky and Kazimir Malevich in 1910-1915. I can only suggest that these painters read the famous encyclopedia by Brokgauz and Efron [10]. A similar definition of 'abstraction' was given in the Encyclopedia Britannica in 1911 [11].

Then we read in the vocabulary of foreign words published in the former USSR in 1964 [12, p. 12]: “*Abstract is distracted (disengaged); Abstractionism, abstract art is extremely formalistic direction in painting, sculpture and graphics (drawing), originated and developed in the 20th century; abstractionists deny realism completely, their works represent a meaningless combination of distracted geometric forms, chaotic spots and lines*”. The next word defined in this vocabulary was “*Abstraction derived from the Latin ‘abstractio’ (elimination, distraction) - a) mental distraction from sides, properties or relationships of subject; b) distracted idea, concept or theoretical generalization ...*” [12]. The next word in this vocabulary was *absurd*. Was not this symbolic? I found similar definitions of the term *abstraction* in the Soviet Encyclopedia (1983), even more, that “*abstract is opposite to concrete*” and “*some currents of abstractionism (suprematism, neo-plasticism) having something in common with the seeking and striving for architecture and industrial art design created ordered constructions from lines, geometric figures and spaces; others (tashism) seek to express spontaneity and unconsciousness of creativity in dynamics of spots and spaces*” [13, p. 10].

Now I understand that this was a mixture of correct and wrong definitions of terms *abstract*, *abstractionism* and *abstract art*.

3. Change the meaning of the term '*abstraction*' in art

Abstract art in this original sense has existed for many years, probably since prehistoric times [4, 2]. There can be no doubt that a new meaning of abstract art was introduced by Russian painters Wassily Kandinski [14] and Kazimir Malevich [15, 16]. They or art theoreticians and critics misused these terms, probably, because of the wrong translation of the term *abstract* into the Russian language. One of the translations of the word *abstract* into Russian was ‘*otvlechenni*’ (отвлечённый, воображаемый, умозрительный) - *distracted (disengaged, discrete, notional)*. In this sense, any form, line, space, dots can be present in accordance with a fantasy and a mood of an artist. And any observer can imagine any object (real or unreal) according to his mood and fantasy looking at such an ‘abstract’ picture, similar to a listener of Chopin’s nocturne. Thus, we encounter a situation in which the original meaning of the word (*‘abstract’* in this case) was changed. This was not the first time in history. Really we encounter the situation when one word (*abstract*) acquired several meanings. For instance, the word *fields* (*polya* - поля) in Russian has three meanings: the area of soil with agricultural product, round ends of a hat or margins on a page. Its meaning depends on the context.

Etymology, as the study of the history of words, their origins and how their meaning have changed over time, is very important in this case, because an unexpected transformation of primary meaning of words with time can give an interesting but not always useful knowledge. For instance, the word '*calculus*' means '*pebble*' (in Latin), as Pythagoreans (the Greek mathematicians) used pebbles before the invention of figures, and certainly this cannot help in understanding the mystery of algebra [17]. Knowledge that word '*classic*' in Latin meant '*fleet*' and then meant '*order*' also cannot help in understanding modern meaning of word '*classic*' [17].

Capricious changes of a meaning, often from the original quality to its very opposite,

follow a perfectly obvious principle: a word designates any quality that can symbolize a certain feeling [6]. An American philosopher of art Susanne Katherina Langer (1895-1985) lists several examples of changes of original meanings of colors. For instance, the word *blue*, German *blau*, derives from *blavus*, a Middle Latin form of *flavus*, meaning, not *blue*, but *yellow* [6]. It is explained by the fact that colors were not always distinguished by their actual spectral values (red, blue, etc.), but primarily as warm or cold, clear or dull. This is correct because these words symbolize opposite sensations or feelings and relate to metaphors. We can hear: cold tone or warm color. The Russian painter Wassily Kandinsky (1866-1944) analyzed colors in a similar manner [14]. Thus, a poet can say instead of *white – black*, metaphorical equivalents *warm – cold*, *clear – vague*, etc. This depends on our imagination and perception, because somebody can imagine definitely opposite that *white* is *cold* (like *snow* or *ice*) and *black* is *hot* (like *black hole* or *hell*). This happens because we deal with *qualitative values*.

Why has it happened that the meaning of the word ‘*abstraction*’ was changed in art in the 20th century from its original use, sense and connotation (*elimination-generalization*)?

I will try to give my vision why 'abstract art' and other modern artistic movements appeared at the beginning of the 20th century. We can use one of famous dictum that development of science and technology takes place but “*there is no progress in art*” [18, p. 10]. Significant achievements were done in science and technology in 1895-1910s. Let me mention only several considerable achievements: the production and detection of electromagnetic radiation (known as X-rays or Röntgen rays) by the German physicist Wilhelm Conrad Röntgen in 1895; the discovery of radioactivity by the French physicist Antoine Henri Becquerel in 1896; the discovery of electrons by the British physicist Joseph John Thomson in 1897; the introduction of quanta (photons) by the German physicist Max Planck in 1900; the theory of relativity by Albert Einstein in 1905 which changed views on space, time, and matter; the formulation of the model of the atom by the British physicist Ernest Rutherford in 1911. Then the works on psychoanalysis by the Austrian psychiatrist Sigmund Freud, the production of automobiles, the first flights by airplanes, etc.

These discoveries and developments in science and technology of course influenced people, their life, thoughts, and psychology. All this could not influence the artistic world. Artists tried to understand these changes and to reply by their works. For instance, French artist Marcel Duchamp (1887-1968) suggested artistic version of “denuding” of matter (after discovering of electron) in his paintings “*The King and Queen Surrounded by Swift Nudes*” and “*Nude Descending a Staircase*” (Figure 4). Duchamp attempted to give visual form to the invisible world in his paintings [19, 20]. Artists sought progress in the field of art and suggested their vision of new phenomena. Thus artists began "destroying" old art in the hope to create something new in accordance to changes of knowledge about our material world. Futurism, cubism, fauvism, Orphism, expressionism, Dadaism, and surrealism in painting; functionalism and constructivism in architecture; symbolism and zaum (Russian ‘заумь’ – ‘transreason, transration or beyondsense’) in poetry; and dodecaphony (atonal music) in music appeared. We can call all these movements by one word *avant-garde*.

a

b



Figure 4. Marcel Duchamp (1912). **a** – “The King and Queen Surrounded by Swift Nudes”; **b** – “Nude Descending a Staircase”

The latter is the French word meaning *advance guard* referring to people or works that are innovative or experimental, particularly with respect to art and culture. *Avant-garde* represents a pushing of the boundaries of what is accepted as the norm or the status quo, primarily in the cultural realm. The French banker and mathematician Olinde Rodrigues (1795-1851) first used the term ‘*avant-garde*’ in his essay “*The artist, the scientist and the industrialist*” (1825), in which he called artists to «*serve as [the people’s] avant-garde*», insisting that «*the power of the arts is indeed the most immediate and fastest way*» to social, political, and economic reform [21]. Over time, *avant-garde* became associated with movements concerned with “Art for art’s sake”, focusing primarily on expanding the frontiers of aesthetic experience, rather than with wider social reform.

We should mention that art has different aims: the reflection of real material and spiritual world, bringing pleasure (hedonistic function), communicative (the ability of art to carry out communication between people), cognitive (education) function, and aesthetic (the creation of beauty) [22]. I would like to put in the first place the *creation of beauty*. Thus the Russian writer Leo Tolstoy emphasized the ability of art to ensure the communication between people, the German philosopher Georg Hegel – possibility to comprehend the ‘*absolute*’ by means of art, Sigmund Freud saw in art getting rid of neuroses [22, p. 38]. Thus each person chooses in art something important for him. This approach to art explains acceptance, delight and admiration (or hostility) by paintings of ‘abstract’ art.

4. Real abstract art is not undefined or ambiguous

You can often hear that ‘abstract’ art is vague, uncertain and indefinite and leaves the viewer to decide what it is. Susanne Katherina Langer began her manuscript written 55 years ago with the sentence “*all genuine art is abstract*” [6]. Then she continued: “The *schematized shapes* usually are called *abstractions* in painting and sculpture”. Schematized is not undefined or ambiguous. Schematized is generalized, universal, common, collective, and comprehensive. Thus *schematized* is opposite to *concrete*. Look at a woman or a man painted on the doors of public toilets. All these paintings are *abstract* because they are *schematized*, reflect all women and all men and not some specific Marie or John, a person of specific age, origin, nation, weight, height, volume, color, smell, etc. If you see a picture with the title “Untitled” in a

museum it does not mean that this is abstraction. If any form, shape, line, or scramble depicted on the list may be 'abstract' this means that any person, animal, machine can be an "artist". A real *abstract painting* or an *abstract sculpture* is a generalized quintessence of some concrete forms. *Abstract* must be concise and recapitulative. An abstract painting or an abstract sculpture consists of forms or shapes, but the opposite is false. Not any form and shape may be abstract.

Not all books on art distinguish *abstractionism* as individual art movement or style. For instance, in chronology of 50 "Isms" during the last 700 years in 1300-2005 *abstractionism* (as art!) is not mentioned at all [23]. But *abstract expressionism* and *suprematism* are mentioned. The latter movement was developed and led by the Russian artist Kazimir Malevich (1878-1935). Suprematists believed they could express themselves through *geometric abstraction* [23]. Even this combination of words deduced (lead into error). *Suprematism* and *abstract expressionism* were invented and defined by artists themselves. They put another sense and meaning which were originally in the term 'abstract'. Such a situation brought misunderstanding in next generations of artists, art critics, art dillers, and wide lovers of art. We should agree that in the best case the paintings of Russian painters Wassily Kandinsky (1866-1944) ("Without name", 1910), Kazimir Malevich ("Black Square", 1915), El Lissitzky (1890-1941) ("Proun 19D", 1922), and a Dutch painter Piet Mondrian (1872-1944) (grid-shaped paintings) may be named *graphical design* [4, p. 240] (Figures 5, 6). They were marked as *modernism* or *neo-plasticism* [23] and not as *abstractionism* (in the term of art). Thus all these movements (*suprematism*, *modernism*, *neo-plasticism*, etc.) were the reduction of painting to a code of shapes, forms, lines and colors in spite of attempts to explain that this is a new language of painting.

Probably owing to works of Ernst Linde [24] and a German art historian Wilhelm Worringer [25], the term 'abstract' entered into art and aesthetics in 1907-1908. Worringer argued that there were two main kinds of art: art of 'abstraction' (which was associated with a more 'primitive' world view) and art of 'empathy' (which was associated with realism in the broadest sense of the word and applied to European art since the Renaissance).

Some of the foundations of 'abstract art' (Malevich, Kandinsky) tried to explain and ground their destruction of old art and creation new one as *abstraction*. Certainly they [14-16] and art historians [25] used wrongly this term 'abstraction' in its original meaning *elimination* and *generalization*. But ... if to use the Russian word 'otvlechenni' (отвлечённый) - *distracted (disengaged)* as translation of 'abstract' into Russian, their paintings really were *distracted* (отвлечёнными).

Let us address the original works "About spiritual in art" (1910) by Wassily Kandinski [14] and "From Cubism to Suprematism" (1915) by Kazimir Malevich [16]. Malevich was not a pioneer of *geometric abstract art*. It is important to emphasize that after the creation of the work of art it does not belong to the creator, and you may speculate what you want. For instance, you can read that «*Malevich was interested in aerial photography and aviation, which led him to abstractions inspired by or derived from aerial landscapes*» [26]. Some Ukrainian authors claim that Malevich's suprematism is rooted in the traditional Ukrainian culture: «*His abstract visual language and non-objective (non-figurative) art called suprematism (which he invented in 1915) drew on the simple values of peasant life and was rooted in the simple values and aesthetics of peasant folk*» [27, 28].

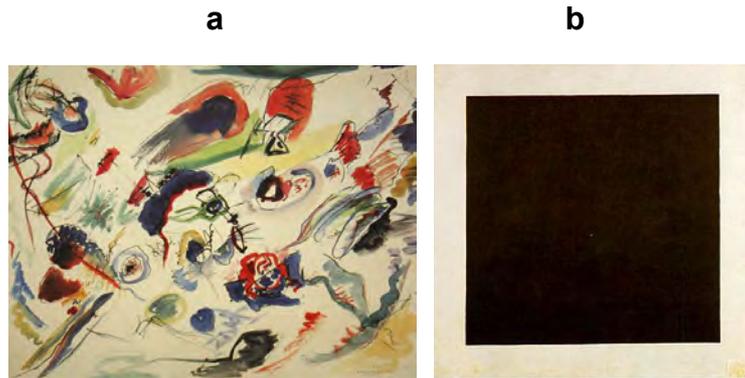


Figure 5. **a** - Wassily Kandinsky, “Without Name” (The 1st Abstract water color on paper), 1910. **b** - Kazimir Malevich, “Black Square”, 1915

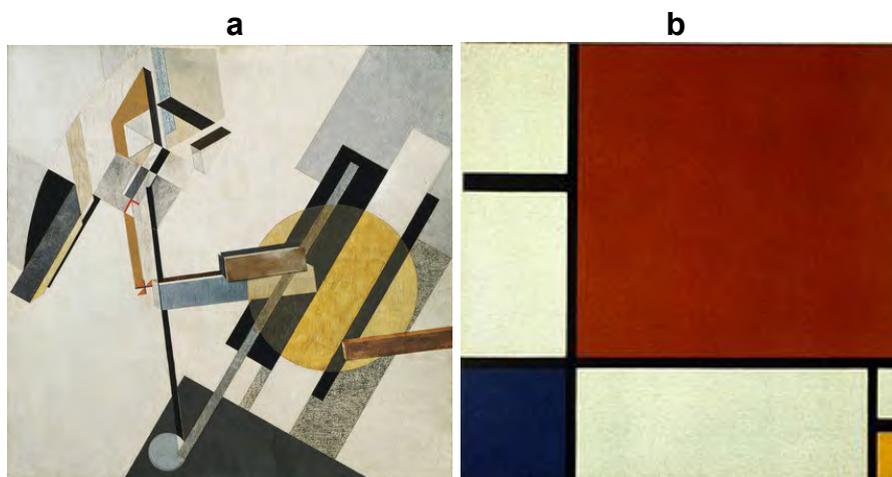


Figure 6. **a** - El Lissitzky, “Proun 19D”, 1922. **b** - Piet Mondrian, “Composition II in Red, Blue, and Yellow”, 1930

The American Asian artist and art scholar Stephen Little suggested the key concepts, styles and issues relating to such *ism*: *suprematism* of Malevich was named as *geometric abstraction*, *monochrome*, *assault*, *spiritual purity*, or *spatial movement*; *neo-plasticism* of Mondrian was named by *grids*, *spiritual order*, and *elementarism* [23].

What did Malevich say about his paintings?

All explanations made by Kazimir Malevich or Piet Mondrian failed because there is no mind line which can be understood by each “middle” person. Kazimir Malevich did not use the term *abstract* from the beginning, but *suprematism* deriving from *suprématie* (in French, and not *suprême*) which means *priority* (*supremacy*) of color problem [15, p. 90]. Taking into consideration the Polish origin of Malevich it is possible that he invented *suprematism* from the Polish word *supremacja* which is similar to the French word *suprématie* and means *superiority*, *predominance*, *prevalence*, *supremacy*, *domination* [15, p. 179]. Malevich begins his theoretical papers in 1915 with a clear thesis of destruction of *old art*: “All old and modern painting before *suprematism*, sculpture, word, and music were enslaved by a form of a model and are waiting of their liberation, in order to speak in its own language and

do not depend on mind, reason, meaning, logics, philosophy, psychology, different laws of causality and technical measuring of life” [15, p. 191]. Malevich writes later: “Overthrow of the old world of art will be written on your palms” [15, p. 201]. Theory of *pointless art* creating by Malevich from 1915 was spread on all kinds of creative works such as painting, poetry, and music [15, 16]. Syncretism (combination) of different arts confessing by Malevich was related to symbolism of the beginning of the 20th century. He used definitions *pointlessness* (without matter, without content), *pointless art* (art without content, matter) and wrote about “*suprematism as pointless new pictorial realism*” [15, p. 216]. Malevich wrote that “*suprematic forms as abstraction became utilitarian perfection*” [15, p. 233]. In other words they (forms) expressed nothing, zero. Malevich wrote about the world as *pointlessness* and called his suprematism by *pointless – abstract art* [15, p. 306]. He left behind large theoretical works which are full of a mixture of interesting thoughts and allogisms. We can conclude from his works that he did not use *abstract* in its original meaning (*elimination, generalization*) but in the sense of *otvlechenni* (отвлечённый, воображаемый, умозрительный) - *distracted (disengaged, discrete, notional)*.

In all the movements of figurative painting of the 20th century, the main component of painting was lost and was absent – *mind*. This was explained by Israeli philosopher of art Tsion Avital [4] and partly by Ukrainian-Jewish scientist Vladimir Koshkin [5]. Vladimir Koshkin describes an *abstraction as a summary* on the example of Picasso’s series of 11 pictures of bull (Figure 7):

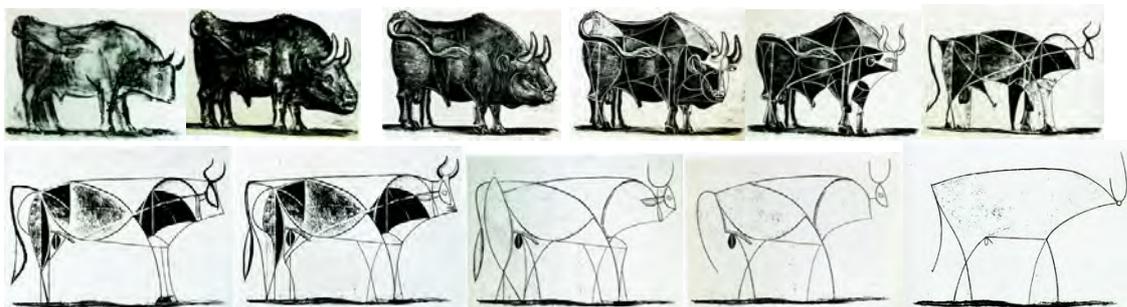


Figure 7. Picasso’s bulls (the example of genuine abstract art)

«Picasso begins from a nearly photographic picture of a bull – with black nostrils, with felt hairs ... Part of details has been already removed on the third drawing – this is still a “portrait” of the concrete bull but a little bit generalized. A bull does no longer smell. Consecutively removing details, Picasso concludes with a symbolic portrayal of “a bull in general” on the last drawing. This is a figurative explanation of the origin of ‘abstraction’ in modern art. But this picture is similar to a portrayal of animals in the caves done many thousands years ago. Primitive people began from symbols! Primitive people were not yet interested in the “individuality” of an animal – this is a source of meat for food or a source of danger. Primitive artists were “symbolists” in the context of abstract meaning “non-detailed”. People of the stone epoch began artistic (and scientific!) understanding of the world from such abstractions. They were the first “formulas” and equations. Similar to modern road signs but in the times when symbols as generalizations and designations of meanings have been just engendered. Symbolic drawing is simpler than “realistic” (technically) picture but this

is quite another matter. Symbolic drawing is more informative than detailed picture: it is remaking information conveniently summarized and gives the opportunity for quick perception and effective acceptance of life decisions. Of course, the quantity of bites (according to the information theory of Claude Shannon) is much more in “figurative” depiction of the bull, but his abstract portrayal gives more such information which will be fixed by our memory – especially during the limiting time of acquaintance and looking at the “portrait” of this character. Particularly if the “personality” of a bull is not interesting for me, but I would like recognize it earlier before I run into in the field. An efficiency of memory and further recognition of generalized portray is more than that of a detailed one. This is a paradox of lack of coincidence between “amount” and “value” of information» [5, pp. 36-37].

Certainly this *real abstract painting* of bulls by Picasso differs from ‘abstract’ painting by Kandinsky, Malevich and others. Sometimes art theoreticians say that in order to understand new modern ‘abstract’ art you should learn the principles of art. Thus we come across with some questions. For whom are the ‘abstract’ paintings intended? Should a person know the principles and basics of painting in order to understand and enjoy pictures? This question probably is similar to the following questions. Should we know the notes and chords in order to enjoy music, or should we know the principles of linguistic and phonetics in order to understand the language which we speak? There is no unequivocal reply.

5. Resume (for Abstraction in Art)

When you listen to “The Dance of the Swans” from the ballet “Swan Lake” by Russian composer Pyotr Ilich Tchaikovsky it is difficult to imagine something else. Tchaikovsky wrote this composition when he observed the swans on the lake in Germany. If Tchaikovsky did not give the name to his composition, what would you imagine? Music creates mood. I feel that many musical descriptions of the dance of the swans can exist. Something similar exists in painting. A painter can create many different compositions with the title “Loneliness”: a tree or a person in isolation, etc. A composer generalizes by means of different combinations of notes. A painter generalizes by different compositions of colors, forms and lines.

Probably *abstract art* which was coined to some painting movements in the 20th century is similar to attempts of creation of international language based only on some stochastic and meaningless sounds. For many people who try to understand and enjoy ‘*abstract art*’ this is similar as they enter a country with a language unknown for them. We know that words consist of letters, but not any combination of letters will give words. Music consists of sounds, but not just any combination of sounds gives music.

What was lost in *abstract art* of the 20th century? Some rules of organization, order and of combination of colors, forms, lines, sounds, and letters.

Now we will describe abstraction in science and technology.

6. Abstraction in Science

Science is an enterprise that builds knowledge about the universe. Science is the systematic attempt to discover and expose [nature's](#) patterns. In short, science appeared as satisfaction of curiosity of people [1].

The driving principle of science is generalization. Its subject matter is really something perfectly concrete, namely, the physical world. Its aim is to make statements of utmost *generality* about the world. In order to create real abstraction we should first eliminate and then generalize. This is exactly that is made in science and technology. Abstraction gives the opportunity to create powerful symbols which may be understood by any person.

Any formula in physics, any written chemical reaction in chemistry, most graphs in thermodynamics and corrosion science are abstraction. For instance, the dependence of corrosion current on electric potential for some concrete system (for instance, iron in aqueous solution of potassium sulphate or nitric acid) can be summarized as a generalized graph (Figure 8).

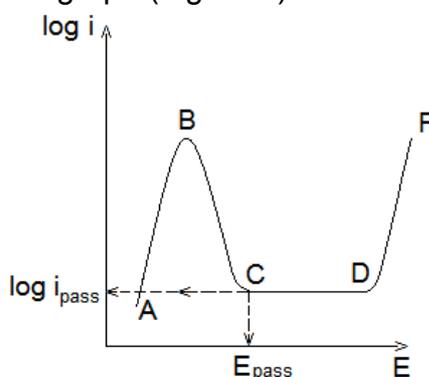


Figure 8. Anodic polarization curve of metals/alloys possessing passive state: E , Volt (electric potential); i , $A \cdot cm^{-2}$ (electric current density) [29]

Many metals and alloys, in certain liquid media, behave in this manner and this generalized graph shows that metals/alloys possess a passive state. This *abstract* graph (see Figure 8) has great practical value and application.

Only photography can show a real picture. When a painter creates his painting of some natural object he makes an abstraction from the concrete matter. In science the situation is similar. When studying concrete material or a specific process, scientists make generalizations. I will describe several examples of such abstractions from physical chemistry.

1. Studying the dependence of air volume on pressure, the French scientist Benoît Paul Émile Clapeyron (1799-1864) suggested in 1834 the equation of state of any hypothetical ideal gas (ideal gas law), not for some particular gas but for all ideal gases (1). The state of an amount of any gas is determined by its pressure, volume, and temperature.

$$PV = nRT \quad (1)$$

where P is the pressure of the gas; V is the volume of the gas; n is the amount of substance of gas (for example, the number of moles); T is the temperature of the gas; and R is the universal gas constant. Any gas irrespective of its composition

(hydrogen, oxygen, helium, etc.) at low pressures or high temperatures behave in a similar manner and this behaviour is described by the generalized (abstract!) equation (1).

- In order to determine the direction of any physico-chemical process (chemical reaction or change of state of a matter) you can use the Gibbs–Helmholtz equation (2).

$$\Delta G = \Delta H - T \cdot \Delta S \quad (2)$$

where ΔG is the change of Gibbs energy; ΔH is the change of enthalpy; ΔS is the change of entropy, and T is a temperature. Thus the generalized (abstract!) equation (2) is related to all physico-chemical processes irrespective of their nature.

- The Arrhenius equation (3) describes the dependence of the rate of any chemical reaction on temperature:

$$\ln k = \ln A - E_a/RT \quad (3)$$

where k is the rate constant of chemical reaction; A is the pre-exponential factor; E_a is the activation energy, R is the universal gas constant, and T is the temperature. Thus the generalized (abstract!) equation (3) is related to all chemical, biochemical and many other thermally-induced processes/reactions irrespective of their nature. Certainly every formula in physical chemistry is the generalization of many particular processes.

Thermodynamics deals with *abstract (generalized)* processes. For instance, you observe water in a puddle (Figure 9).

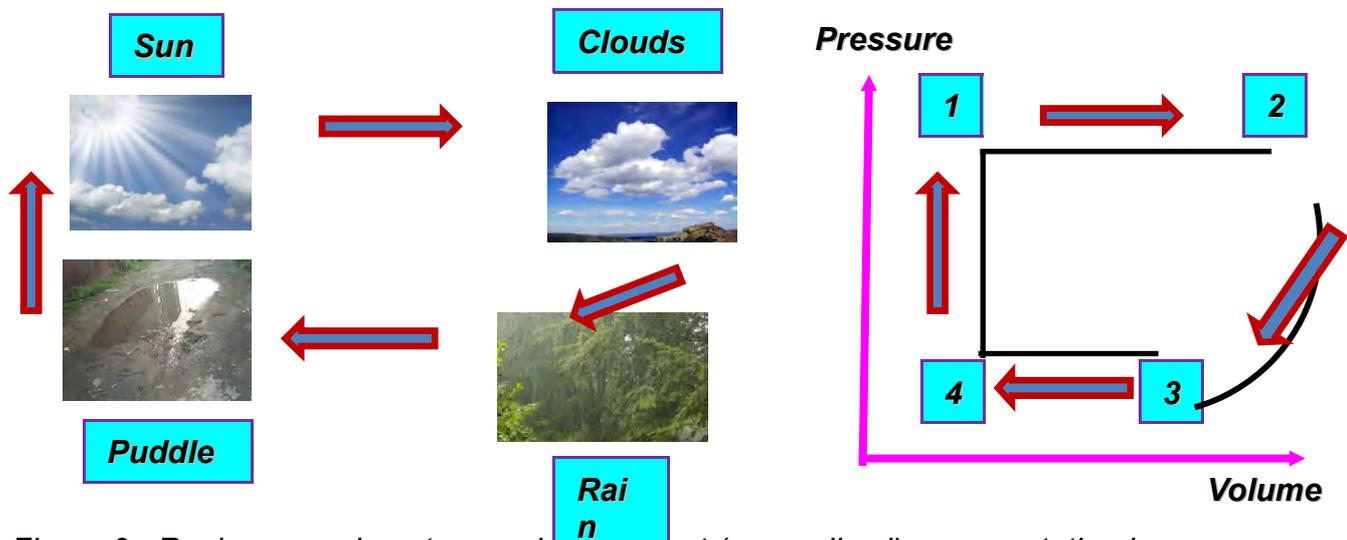


Figure 9. Real process in nature and its abstract (generalized) representation in thermodynamics by the graph 'pressure – volume' (description is in the text)

The sun is shining and water is evaporating. Thus, the volume of water increases at constant pressure: process 1-2 in the diagram 'pressure – volume'. Then clouds are formed from water vapor. Thus, pressure and volume of water vapor decreases: process 2-3. Then rain is formed from the water vapor. The volume of water vapor drastically decreases (it is rain): process 3-4. A puddle is formed and sun rays heat water to original pressure: process 4-1. In thermodynamics all this is generalized as an abstraction in the 'pressure – volume' diagram. Water in the puddle, sun, clouds

and rain disappear from the 'pressure – volume' diagram since it is not important. Thus all similar processes in nature and industry are described with such a graph. Thus we showed the power of 'abstraction' which is a real generalization of many chemical and physico-chemical processes.

- Here is an example from materials science. The Israeli scientist Dan Shechtman detected quasiperiodic crystals in 1982 when studying the particular alloy titanium aluminide by means of an electron microscope. A quasiperiodic crystal (shortly, quasicrystal) is a structure that is ordered but not periodic, namely, which has a forbidden symmetry of five (Figure 10).

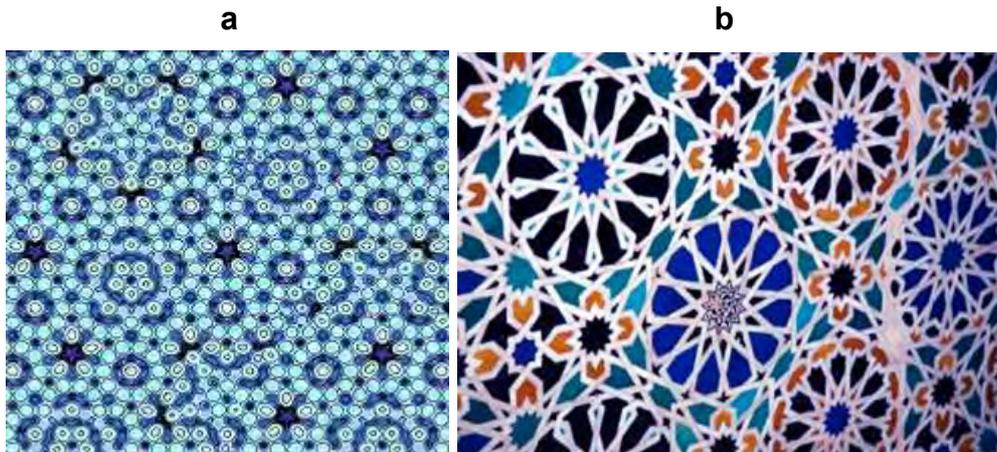


Figure 10. **a** - Atomic model of an aluminium-palladium-manganese (Al-Pd-Mn) quasicrystal surface [30]; **b** - Mosaics, which are not periodic are found in the medieval Islamic mosaics of the Alhambra Palace in Spain [31].

Dan Shechtman received the Nobel Prize in chemistry 2011 for this discovery. Since the original discovery by Dan Shechtman, hundreds of quasicrystals have been reported and confirmed. Thus, the quasicrystals are no longer a unique form of solid; they exist universally in many metallic alloys and some polymers, even in nature. Nowadays we can say that a quasicrystal is a generalization of a large group of artificial and natural crystals and its representation is found even in art (ornaments). Aperiodic mosaics, such as those found in the medieval Islamic mosaics of the Alhambra Palace (Spain) and the Darb-i Imam Shrine (15th century, Isfahan, Iran), have helped scientists understand what quasicrystals look like at the atomic level. In those mosaics, as in quasicrystals, the patterns are regular - they follow mathematical rules - but they never repeat themselves (see Figure 10).

7. Abstraction in Technology

Technology is the conversion of natural resources into tools for the satisfaction of needs and requirements of people [1]. Let me give some examples from everyday life.

- You drive a car which operates on a gasoline or diesel engine, named also a heat engine. All these heat engines are powered by the expansion of heated gases. A heat engine is a system that performs the conversion of heat (thermal energy) to mechanical work. A brilliant example of abstract vision

presented by the French engineer and scientist Nicolas Léonard Sadi Carnot (1796-1832) in 1824 is the ideal Carnot cycle which scientifically clearly explains the work of any steam engine. Using an abstract way of thinking Sadi Carnot wrote in his book "*Reflections on the Motive Power of Fire*" that «*it was necessary to establish principles applicable not only to steam-engines but also to all imaginable (meaning abstract) heat-engines*». Of course, there were no automobiles in that time, but many ships worked on such heat engines. Carnot analysed a *generalised* heat engine, suggested the cycle and another French scientist Clapeyron later built it in a graphical *generalized* (*abstract!*) form 'pressure – volume' (Figure 11).

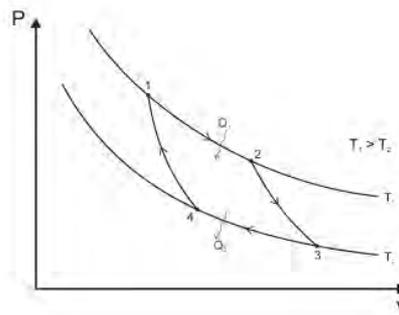


Figure 11. A Carnot cycle illustrated on a 'pressure-volume' (P-V) graph explaining how any (generalized or abstract) heat engine works

This is classical generalization (abstraction) of all ideal heat engines.

2. Here is another example. You use gasoline or diesel fuel in your automobile. How are they produced? The process of producing of fuels from crude oil is called *distillation*. Distillation is a method of separating a liquid homogenous mixture into fractions based on differences in boiling points of its components (Figure 12).

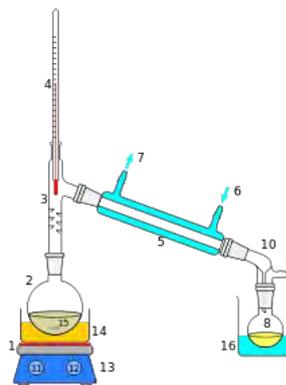


Figure 12. Laboratory display of distillation

It does not matter which liquid mixture is distilled. You may distill crude oil into fuels, salt water and receive pure (distilled) water, fermented aqueous solutions and produce alcohol beverages, liquid air and produce pure oxygen and nitrogen, ordinary water and produce 'heavy' water, liquid hydrogen and produce deuterium (heavy isotope of hydrogen). Thus distillation is a

generalization of physical process of separation of any liquid homogenous mixtures. This generalization (abstraction!) helps the chemical engineer to calculate parameters needed for separation and producing pure components.

8. Abstraction and Expression

Any representation in memory is a sum, an integrative mixed image. Try to imagine any picture or phenomenon that you observed in nature, in a museum, or in a theatre. Try to recollect some details, and I think that this is not simple. We have difficulties of *expression* of some dynamic image which was received through *perception* including organs of sense, mood, spiritual condition, emotion, etc. Thus we want to *express the abstract* of image (generalized picture). As a result *abstract expressionism* developed by Jackson Pollock appeared: «*I want to express my feelings rather than illustrate them*» [32]. Is this an art? Let me cite Vladimir Koshkin: «*I do not understand and do not feel what Pollock wanted to say in his colour pictures under different numbers. Art however addresses not only feelings but also understanding*» [5, pp. 39-40]. Then Vladimir Koshkin concludes with a similar sentence as an epigraph to the book [4] by Tsion Avital: «*Delights of people before the "Black Square" by Malevich are seemed by exclamations of citizens from the tale "The Emperor's New Clothes" by Hans Christian Andersen*». Both Tsion Avital and Vladimir Koshkin conclude that "*art is combination of feeling and intellect (mind)*" [4, p. 15; 5, p. 40]. You may read the same in the epigraph in the 'Overture' (beginning of this paper). In any case why do I personally and many people like some pictures by Jackson Pollock (Figure 13)?



Figure 13. "Number 5" (1948) by Jackson Pollock

9. Art and Brain

Mathematics explained the art of Jackson Pollock and why people enjoy his paintings [33]. Mathematics showed that Jackson Pollock's famous drip paintings are fractals. Fractals are complex geometric shapes that have been studied by mathematicians since the 1970s. The term 'fractal' was first used by the French

American mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin 'frāctus' meaning 'broken or fractured', and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature (Figure 14). Clouds are not spheres, mountains are not cones, and lightening does not travel in a straight line. The complexity of nature's shapes differs in kind, not merely degree, from that of the shapes of ordinary geometry, the geometry of fractal shapes [34, 35].

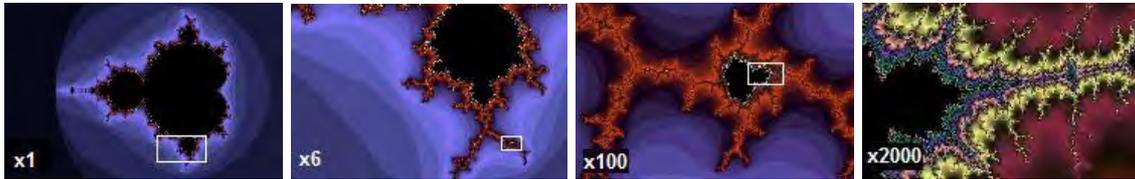


Figure 14. The Mandelbrot set illustrates self-similarity. As you zoom in on the image at finer and finer scales, the same pattern re-appears so that it is virtually impossible to know at which level you are looking [35]

Fractal analysis can be used to distinguish Pollock's drip paintings from imitations. The American scientist Kate Jones-Smith showed that doodles that she could make in minutes using Adobe Photoshop were as fractal as any Pollock drip painting, vividly refuting the physicist Richard Taylor's claim that Pollock was able to generate fractals by hand only because he had attained a mastery of chaotic motion. A defining feature of fractals is their self-similarity. They look the same if magnified. Sometimes the self-similarity is visible to the eye, as in the famous Koch snowflake, which is composed of a hierarchy of ever smaller equilateral triangles. The Koch snowflake (also known as the Koch star and Koch island) is a mathematical curve and one of the earliest fractal curves to have been described [36] (Figure 15).

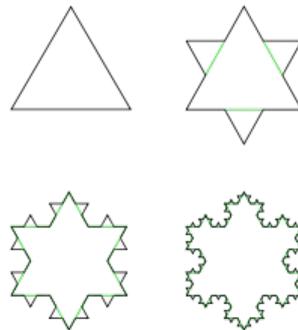


Figure 15. The first four iterations of the Koch snowflake [37]

It is based on the Koch curve, which appeared in a 1904 paper titled "On a continuous curve without tangents, constructible from elementary geometry" by the Swedish mathematician Niels Fabian Helge von Koch. More often the self-similarity is statistical and can be detected only by computer analysis using a technique called box-counting. Fractal analysis involves placing a grid over an image to search for replications of geometric patterns. In this case, it also involved colour separation and an analysis of each layer of paint. The data is plotted on a graph and a "box-counting curve" that resembles a staircase is generated. This curve is inspected to see if it meets the fractal authentication criteria [38].

It is obvious that art is transformed in our brain. Neurologists entered this field to understand what happens in the brains of artists and lookers [39-41]. Neurology is the medical specialty related to the human nervous system. The nervous system encompasses the brain, spinal cord, and peripheral nerves. According to an English scientist on neuroesthetics Semir Zeki, «...most painters are also neurologists» [39]. American psychologist Patrick Cavanagh talked the same about «*the artist as neuroscientist*» [40].

Israeli scientist Idan Segev explains why many people like some pictures by Jackson Pollock. “*What is there in the human brain that takes pleasure in art?*” [42]. Once more, his technique consisted of spraying, dripping and pouring paint on canvases (see Figure 13). His works are constructed of particles, which are mathematical expression of a geometric form that is composed of copies of itself. In other words, even when you look at only a part of it, you see the whole picture [42]. A particle refers to coverage of a surface with paint that is measured on a scale between 1 and 2. This is the *fractal dimension* D, an important parameter for quantifying fractal pattern’s visual complexity [43]. This parameter describes how the patterns occurring at different magnifications combine to build the resulting fractal shape [34]. For Euclidean shapes, dimension is described by familiar integer values – for a smooth line (containing no fractal structure) D has a value of 1, whilst for a completely filled area (again containing no fractal structure) its value is 2. However, the repeating patterns of a fractal line cause the line to begin to occupy space. The denser the coverage, the closer it gets to 2. But another characteristic of the particle is that it is composed of repeating patterns and it doesn’t matter at what resolution you look at it. «*Pollock didn’t know that he was painting particles, but researchers who examined his paintings found that over the years, the particle dimension in his paintings increased. Basically, brain researchers had people look at particle paintings and asked which particle scale appealed to them the most. It seems that we most enjoy or are most drawn to looking at paintings with a 1.4 particle scale (fractal dimension D). Beyond this level, it becomes too complicated for our brains. In his last paintings, Pollock painted on a 1.7 particle scale*» [42]. Our question is why 1.4 and not 1.2 or 1.6? There is no reply for the time being.

Has neuroscience been able to pinpoint the spot from which creativity derives?

«*In neuroscience there is a new field called neuroesthetics. It’s a term that was coined by an English researcher, Semir Zeki. This field asks what is the biological basis, the neurological basis, of the need to create and enjoy art. Researchers look at, for example, which particle dimension appeals to us. Today it is also possible to scan the eye while it is looking at an work of art and to see what is observed. But to be honest, it’s a little absurd, since in the end this doesn’t really answer the question of why we enjoy art* » [42].

In my opinion, perception of the works of art and enjoying art is connected only to the brain of each person. There is no general quantitative criteria why “I like or do not like” this work of art. This is similar to the question ‘*what beauty or love is*’. Each person sees in his own way through the brain and the organs of senses. And this depends on his state, media, where he grew up, education, experience, age, mood, and even health. Neuroscientists study biochemical processes occurring in the brain but today this is like alchemy in the middle ages. As science and technology progress quickly I hope that the way for deciphering of biochemical processes

occurring during enjoying (or not enjoying) art will be shorter than the way of alchemists to modern chemistry.

10. Epilogue, or Instead the End

An interesting and even paradoxical situation is formed in the world of art. People have misused the term 'abstract art' since the beginning of the 20th century and will continue to use the new connotation of 'abstract' forgetting its original meaning. People of art say that 'abstract art' is something immaterial and express an idea (an 'abstract') of personal perception. They forgot that 'abstract' is simultaneous elimination (simplification) and generalization. They made the first stage of elimination, did not generalize, and remain with this situation. Other people (non-artists, even scientists regarding 'abstract art') accepted this and use the term 'abstract' in the new simplified connotation.

I am not sure that it is possible to reach a consensus between people in society not to use the term 'abstract art' because it was changed and used in contrast to its original meaning (generalization). It is possible to reach consensus in science and technology, but in humanistic disciplines and art it is impossible. For instance, there are many scientific and technical international committees where scientific societies decide about the definition of each scientific and technological term. Each scientist and engineer uses terms only in one context, e.g., corrosion, acoustic emission, electric potential, etc. You will find exact definition of such terms. You cannot use some term in science and technology in a new interpretation. Nobody will understand you. It is forbidden by international scientific societies.

But ... in art there is no single (unified, common, uniform) definition of the term 'abstract' and we will continue to use it in the new interpretation of individual perception as it has been used since the beginning of the 20th century.

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