Meeting Alhambra

ISAMA - BRIDGES 2003

Conference Proceedings

University of Granada
Granada, Spain

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Computers, Mathematics And Conceptual Art

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Abstract

The connections between mathematics and conceptual art are not obvious. Mathematics would seem the most precise of sciences, not governed by physical measurements and observations, but by calculation and proof. Conceptual art, on the other hand, is often ephemeral and ambiguous. Its very existence as art can be made open to question, a process that can be deliberately manifest in the work itself. In spite of these seeming differences, the similarities are numerous, natural and quite significant. This paper explores these connections and their importance to those with an interest in mathematics and art, including artists, educators and others involved in interdisciplinary practices. It briefly introduces the evolutionary history of conceptual art and the popular perception of what it is, defines the essence of conceptual art as a metaobject, and shows that mathematics is essentially conceptual, including the presence of a metaobject. In order for mathematical ideas to be accepted into artistic practice they must have an art theoretical position; that position is akin to the position that has been taken by conceptual art.

1. Introduction

1.1 Terminology. I must start by clarifying my usage of the terms "subjective" and "objective." My definition of "subjective" will be: belonging to the perceiving *subject* rather than the *object* of perception. This is straightforward enough, but it leads to ambiguities in the use of "subject." In the sentence, "John saw a picture of a house," "John" is the subject, "picture" is the object. Throughout this paper I will use the terms "subject" and "object" in this sense. It would be quite natural to say that the subject of the picture is a house, i.e. what the picture is about, but this usage is confusing. I will refrain from referring to the "subject" of a work of art, but instead will use the terms "content" and "meaning." Although arguments could be made for subtle distinctions, these words are useful enough.

The term "objective" is more problematic. Skipping over its uses as a noun, we find that the adjective can mean simply: unbiased. Although this is probably the most accepted meaning of the word, I prefer a more restrictive definition. I will use "objective" to refer to qualities that are inherent in the object of perception rather than the perceiving subject, where the object has some physical presence. Although qualities may be manifest in the object, I don't mean to imply that they are necessarily obvious nor of undebatable meaning.

1.2 Background. My own interest in the connectedness of computers and conceptual art began with a whimsical piece, titled *Generations of a House*, created as a combination of CAD images and text. It was created as a conceptual piece. Neither the images nor text had any autonomous meaning. The content of the work was the idea. All art is an interplay of subject and object. Even the most radically conceptual art projects cannot exist without some objective representation. Although someone could suggest the existence of a work without a subject, that would be hopelessly regressive. All objective works are to some degree subjective. The CAD drawings for *Generations of a House* were created, for the most part, by varying the parameters of a spiraling algorithm as applied to a simple house drawing. The result was

recorded as graphic files and the CAD drawings were undone. It was conceptually important to me, at the time, that the original drawings be undone and not simply deleted, since the work was dealing, on one level, with the ontology and epistemology of the virtual objects. I have two hard copies of the piece, but other than that it exists entirely in electronic media. Subsequently, I built a sculpture based loosely on the generations, developed CAD as-built drawings of the sculpture into a series of prints and wrote a paper on the whole process. [3] In that paper I proposed an animated version of *Generations of a House*, which I have recently completed. I have also animated the as-built drawings. I have come to regard all of these, including the paper, as parts of a larger (and perhaps continuing) conceptual work. Other than published versions of the paper and a few prints, none of it exists in any but electronic form.

1.3 Conceptual Art. Artist Sol LeWitt coined the term "conceptual art" in 1967 and essentially defined it by saying, "In conceptual art the idea or concept is the most important aspect of the work." The purpose of this paper is neither to debate what conceptual art is, nor to attempt any but the broadest categorizations of conceptual art, so I'll leave the general definition at that and elaborate only as necessary by example.

Prior to the birth of modernism, as marked by the rise of impressionism, all art was fundamentally objective. The art object itself was the bearer of meaning and beauty. It may have been Victor Hugo who put the advent of modernism at the separation of the ideas of art and beauty. Impressionism and the art that followed became more and more subjective. The name "impressionism" itself suggests subjectiveness in that the content of the work is an impression to be shared by artist and subject. It was not long before Marcel Duchamp attempted to "return art to the service of the mind," with the "readymade," a seemingly ordinary object exhibited as art, such as *Bottlerack* and the notorious *Fountain*; Duchamp's attitude was that they became art because he chose them; he would take an ordinary object, place it so that its useful significance vanished under a new title and point of view, and create an essentially new object." More on Duchamp later.

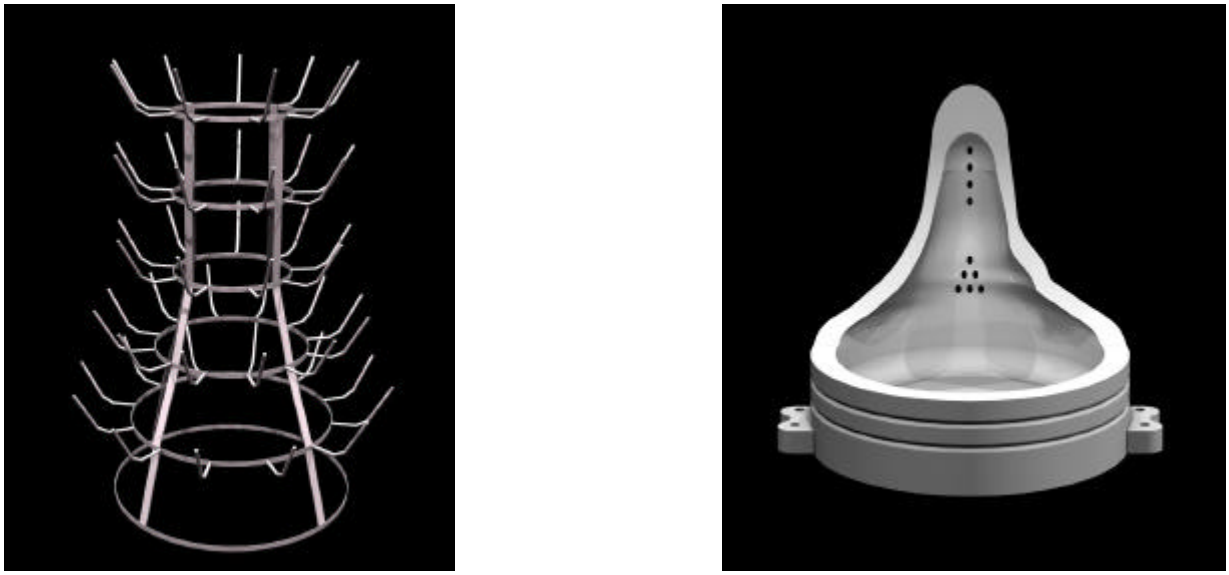

Figure 1: Readymades, *Bottlerack* and *Fountain.*

Except for brief flirtations, nothing that could be construed as conceptual occurred again in art until the 1950s when Robert Rauschenberg and others began to challenge some of the prevailing assumptions of the art world. Rauschenberg questioned the supposed spontaneity of abstract expressionism, the prevailing school of the time, by creating identical paintings. He questioned the autonomy of the art object by obtaining a drawing by the artist Willem de Kooning, erasing it and offering the blank paper as his own artwork. He created what he called the combine painting, something like a collage/sculpture. And he introduced time into his works through light paintings and "happenings." Although conceptual art would not be defined as such for another ten years art and artists were, at this point, essentially freed from all existing conventions. "'Conceptualism'," for better or worse, "has come to stand in some quarters for the array of contemporary practices that do not conform to conventional expectation of art exhibitions showing hand-crafted objects for aesthetic contemplation. In this sense, 'Conceptualism' becomes a negative catch-all for what conservatives of various stripes do not like about contemporary art."[6] And, I might add, what they do not understand. As with all subjective art, understanding is a key to appreciation. Which is not to say that one must like everything, but simply to recognize that art's function is to ask difficult questions as well as provide easy answers.

The transition of art has not simply been from objective to subjective to conceptual. First of all neither objective nor subjective art has fallen by the wayside. The current entry of applied design into the field of fine art certainly suggests a new interest in objectivity. Secondly, I would like to suggest that conceptual art falls into two categories, which I will call metaobjective and metasubjective.

Rauschenberg's work can serve to illustrate both concepts. I suggest that *Erased de Kooning Drawing* is objective, since its initial meaning derives from the object itself. But it is also necessarily subjective to the extent that the blank paper would have very little meaning without the subject's knowing what it is. Judy Chicago's collaborative work *The Dinner Party*, which consists of a myriad of meticulously handcrafted objects in an installation, is objective in that it is dependent on its objectiveness for the overall concept. It is subjective in its meaning because there is information that the subject needs beyond the objects themselves. These are works that I would call metaobjective, and the works themselves become metaobjects; conceptual objects.

With subjective art, the objects are not without meaning, but it is up to the subject to derive that meaning. Monet's haystacks, for example, are not without inherent beauty. But they are much more significant when we realize that they are part of a series that represents an investigation into the nature of light. With Picasso's *Guernica*, arguably the greatest work of the 20th century, it is almost essential for the subject to know the context to appreciate its power. Since Rauschenberg's "happenings," art has come to be manifested in more and more ephemeral ways, like events and installations. The objectivity of these works may lie only in documentation. Conceptual art often calls upon the subject to be a participant in creating the work or to become part of the work itself. These are works that I would call metasubjective.

With a working idea of what conceptual art is (and I probably use a much broader categorization than others, including many artists themselves would), we need a term to distinguish other art. "Non-conceptual" comes to mind, but that negatively implies art with out any concept. I am going to use the term "ordinary art," but without any implication of banality. In ordinary art, the object and subject are not symmetrical with respect to the work. The object is almost invariably contained within the work and often is the work. The subject is seldom contained within the work. Conceptual art can and often does blur those distinctions, so the subject-object dichotomy becomes false at the metaobjective-metasubjective level. But the asymmetry remains. Although I have suggested metasubjectivity, I don't mean to suggest that there is a metasubject even though a conceptual work must contain a metaobject.

2. Mathematical Metaobjects

2.1 Subjective or Objective? Is mathematics subjective? Although it may seem to be objective in the sense of being inherently provable and not open to subjective interpretation, there are no physical mathematical objects, only representations of ideas. But, in the sense that it is independent of objective reality, it can be construed to be more precise. Mathematics easily allows expressions that are smaller or larger, by any order of magnitude we choose, than anything conceivably possible in particle physics or cosmology. If any smaller particle or larger dimension of the universe is proposed, mathematics can simply halve or double it. The universe is finite, but mathematics can represent infinity. The universe is quantized, but mathematics can represent the infinitesimal. Mathematics is a world of ideas. But do there exist mathematical truths independent of a subject?

2.2 Recursions and Fractals. Let us look for a moment at fractals and infinitely recursive sets. These can be identical, in which every layer is the same as every higher or lower layer; or they can be similar, in which every layer only resembles other layers. The Mandlebrot set is in the latter category, and technically it could be said that identically recursive sets are subsets of similarly recursive ones. For the sake of simplicity, consider a set of squares in a 3x3 square arrangement. Every square is composed of 9 smaller squares and is part of an array of 9 squares making a larger square. I can describe this set so that it is easily understandable, but how well we can really comprehend an infinite set is questionable. Interestingly it is much easier to picture the increasingly smaller parts of this recursion than the larger.

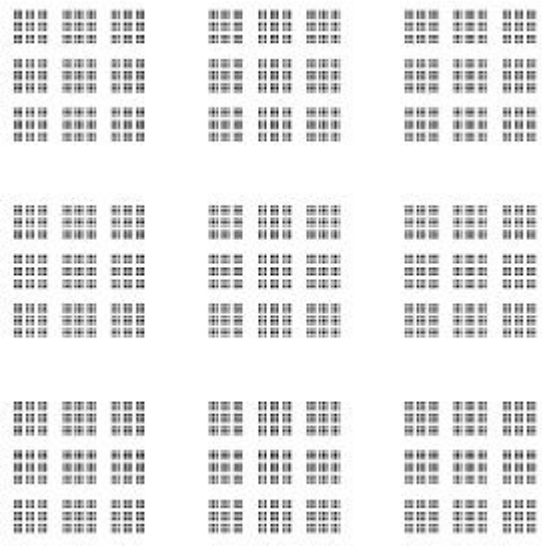

Figure 2: A simple recursive set of squares, five levels deep.

But how can I represent this set? In Figure 2, five layers are visible. There are 3^8 of the smallest square. That's a lot but far short of an infinite number. With a computer we could represent this set by allowing the subject to zoom in or out. Zooming in repeatedly would reveal an ever-increasing depth of recursion. But the computer that did this could never hold anything more than a finite representation of the set. As we zoom in again and again, at some point the computer will stop "counting" the squares that are no longer part of the immediate representation. The set can never exist except as finite representations of an idea. Figure 2 was created in a CAD program by repeatedly array copying a square. There <u>are</u> only five levels (a sixth exceeded the limits of my computer.) I doubled the size of the image over a number of frames and recorded this as a video file. (Representations of the Mandelbrot set often involve

magnifications on the order of a million.) Then I looped the video. The resultant looped (and therefore faked) representation of the infinite recursion is indistinguishable from any possible representation of the actual recursion. The surprising and, perhaps, counterintuitive epistemological conclusion is that these representations cannot in anyway be construed as subjective. But, can they be truly objective without an object? I think the answer is that this infinite recursion is metaobjective, not in the sense that it derives meaning from an object, but in that it is itself a metaobject. By extension we can create a class of mathematical metaobjects that exists outside the ontology of ordinary objects. These would consist of ideas that can be represented as an object, either verbally or graphically. Math-art could be defined as an artistic representation of a mathematical metaobject. What constitutes an artistic representation I leave to the artist.

2.3 Readymades: Duchamp and Poincaré. "Duchamp took particular interest in the work of the great mathematician Henri Poincaré, and much of his art represents a novel and systematic application of Poincaré's views on the nature of time, space, causality, probability and even human creativity itself."[1] The connection between proto-conceptualist, Marcel Duchamp, and modern mathematics and physics, particularly to Henri Poincaré, is one that has been elaborated recently through the work of Duchamp scholar Rhonda Roland Shearer and her late husband, Harvard biologist Stephen Jay Gould. In November 1999, Shearer hosted a symposium at Harvard called *Methods of Understanding in Art and Science: The Case of Duchamp and Poincaré*. "'Discovery is selection,' Poincaré argued. 'The real work of the discoverer consists in choosing between…combinations with a view to eliminating those that are useless.' However, he went on to say that this unconscious work doesn't supply a result 'readymade.' What it produces are merely points of departure for deliberate effort."[4] Interestingly enough, recent studies have shown that Duchamp's readymades may not really be off-the-rack items at all, but clever imitations constructed by Duchamp. Similarly, Duchamp alleged that another of his works, *3 Stoppages Étalon* (3 standard stopping points), was created by dropping threads from a height of one meter and fixing them in their chance arrangement. This may not have been the case at all, since it seems Duchamp deliberately manipulated them. He was certainly capable of using deceptions as points of departure for creating extra levels of coding. (Although probably impossible to prove, Duchamp's intent in fabricating readymades may simply have been to preempt any off-the-shelf forgeries.)

2.4 Generative Algorithms and Chaotic Structures. My own work with math in art began with an interest in the role of chaotic and semi-chaotic forces in shaping the built environment. I created a conceptual work using a computer algorithm to generate objects. It was a simple spiral with a limited number of parameters: the spiral axis, the number of copies, degrees of rotation, total offset, and a scale factor. Slight changes in the parameters could produce major changes in the outcome. I controlled the outcome by controlling the parameters; I had a fair idea what the result would look like, so it was not entirely random. Because the small parameter changes were amplified, the generations could mimic chaotic processes on a very elementary level. Also, I could and did select the outcomes that pleased me and rejected the ones that did not. But I did not draw preconceived objects.

Duchamp's infamous *Fountain* is often described, even by Duchamp scholars, as if it were just another of the readymades, when in fact he submitted it under the pseudonym, Richard Mutt, to an exhibition supposedly open to anyone who had paid a fee. It was rejected which was probably Duchamp's intent (and subsequently disappeared.) The conceptual significance lies in this rejection, over which Duchamp had no direct control.

Conceptual art often begins with an artist setting a process in motion, unsure of the outcome. The concept, and therefore the art, lies in the processes as well as the outcome. The processes may be truly chaotic or simply generative. Often the subject or multiple subjects are called on as participants in the process, so that the work becomes metasubjective. The artist may grant the subject conscious creativity or simply create a random process; in either case the outcome is chaotic in the ordinary sense of the word

and may be chaotic in the mathematical sense. It is not unusual for nonsubjective chaotic forces to be used as processes in conceptual art. These are often natural processes such as animal movements, plant growth, weather or the effects of time itself. But, whether generative or chaotic, these processes are mathematical metaobjects. The representation may lie in the outcome itself, or it may lie in documentation of the process and/or the outcome.

3. Interdisciplinary Ideas and Mathematical Art

3.1 Modernism. The beginnings of the modern age brought extremes of change in many areas of thought. In mathematics and physics Newtonian determinism came into question. Darwin changed the fundamental assumptions of biology. Painting moved from classicism and romanticism to impressionism to the multiple styles of postimpressionism. Sculpture was removed from its pedestal and, free of architectural context assigned new meanings. Painting, freed by photography from pictorial necessity, moved toward abstraction, while photography and finally motion pictures became new art forms. Mass industrialization changed all existing social and economic structures and fueled conflicting political-economic paradigms to global proportions.

But modernity rapidly ran its course. The rupture came not from any resistive reaction, but from the discovery of the internal inconsistencies of the basic paradigms of the modern episteme. Gödel questioned the fundamental assumptions of mathematical systems. Chaos and fractals presented, not only new challenges in mathematics, but new links to the physical world and the arts. As uncertainty in physics gave way to quantum mechanics, epistemological questions of science became ones of ontology. New mechanisms of evolution, but not challenges to basic Darwinian assumptions, were proposed by none other than Stephen Jay Gould. Art began to question its own validity and history, as well as the role of the artist. Information rather than industry became the basic commodity of postfordian globalization. Social theory evolved new ways of understanding cultural contexts and meanings.

3.2 The Paradox of the Postmodern. Information theory equates information and entropy so that increasing information increases disorder. "What we fear most immediately is not that the universe will run down, but that the information will pile up until it overwhelms our ability to understand it." As the volume of information increases, so does the magnitude of information distribution. "For the alliance between entropy and information to be effective, information had to be divorced from meaning…"[2] Although that may seem paradoxical enough, the true paradox of the postmodern is that, as the supply of information increases, so does the desire to know more about more things: Not so much a demand for information but a demand for understanding. If this demand is fed by an ever-increasing supply of information, then the result is the decreasing value of that information. This makes necessary ever-sharpening critical skills; elimination of useless information is, in short, creativity.

3.3 Computers. Computing machines, originated in mathematical theory, operate using mathematical principles and are an all-important tool in today's mathematics. They are ubiquitous. It is no exaggeration to say that they have changed the way we see the world. In some art forms computers have all but replaced traditional tools. But ironically, in many areas where computers have had the most impact on day-to-day practices, they have done little or nothing to influence the underlying paradigms of that practice. Graphic arts are now computer arts; computer techniques are pervasive in movie making; contemporary architecture and design could not exist without CAD. Yet in these areas computers are little more than expanded tools. They make things easier, faster, more realistic, but they haven't changed the essential art forms. Computers have changed the arts on an intrinsic level through altered cultural awareness of new paradigms. Without computer computations, development and representation of chaos and fractals would not be possible. These in turn have become so thoroughly integrated into cultural consciousness that they cannot help but be a major influence.

3.4 Seductive Representations and Other Pitfalls Along the Way. Sitting at a PC I can, with a few basic skills, create simple or incredibly wondrous objects or animations. I can change shapes, rotations, number of copies, size, materials and so on. Each of these properties has a large but, in practice, limited number of parameters. But the number of combinations is, for all practical purposes, unlimited. Out of these I can create renderings and videos that may be uninteresting, or can be complex and beautiful. Long before home videos, the popular press expressed the sentiments of a few overly enthusiastic educators that super 8 movies would put the tools of filmmaking in the hands of a whole generation of children. This, they said, would in turn produce a whole generation of great filmmakers. The cynically true answer was, of course, that although previous generations of children have had pencils and paper, this never produced a plethora of great writers. The point being that it is talent and not medium that makes art.

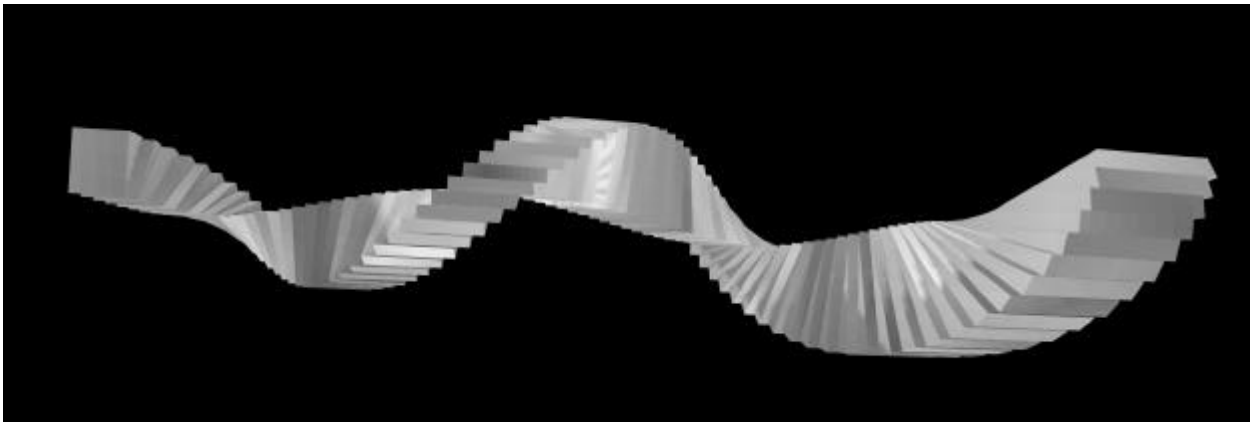

Figure 3: This is not art, this is a doodle.

I can "draw" at a computer or I can doodle with a pencil, but computer drawing is more seductive, because there is an element of surprise. I don't always know how things will turn out, either because the computer generates the drawings, or because it expands my skill level considerably. I can save electronic or hard copy representations that are very beautiful, but are they art or just doodles? In the case of computer drawings for a particular end where the computer is just another tool (like an electronic airbrush), we can answer this just as we would for any other medium of representation. In the case of computer or mathematically generated works that essentially "draw themselves," the answer must be that the art lies in the concept. Beautiful representations are just that, and we must not be seduced into mistaking them for the art.

3.5 Originality and creativity. Originality is part of creativity. Creativity without learning is rare because contexts must be learned, and without a context there can be little originality. A common reaction of the uninitiated to abstract expressionism is "I could do that." This attitude is easily extended to conceptual art: "It's not art because I could do it and I'm not an artist." Neither artists nor mathematicians nor scientists beyond the student level should do what has already been done. Duchamp could pick a readymade and call it art. Appropriated images play an important role in postmodern practice. It works for them, why doesn't it work for us? Because art is contextual, just as science is contextual.

Much of high school mathematics involves proving theorems. Just because a high school student can see that $9 + 16 = 25$, that doesn't make him Pythagoras; but understanding the Pythagorean theorem through the exercise of proving it sharpens skills, an important part of the educational process. So it is with students of the arts (which we all are), Understanding is essential to creativity.

3.6 Mathematical and Computer Art. Artists, mathematicians, computer scientists and educators who are attempting to integrate art and math must be aware of the conceptual foundation and nature of their work. In spite of postmodern questioning of the role of the artist (or author), someone is always responsible for a work of art, be that a painter or a conceptual artist who calls a readymade "art." Algorithms and computers can be used to compute, plot or draw, but there still must be a user. We can imagine art made without a human hand, but works made without a human mind are not art. Succumbing to the seduction of representation, we can easily turn a computer loose to create endless drawings, but the art must lie in the concept and not in the drawings, and someone is responsible for the concept. When we create art from mathematics, the art lies in the mathematics and not in its representations.

4. Afterword: Why Is All This Important?

4.1 A Conceptual Work Unexplained. The photographs of Marcel Duchamp's works that accompany this text are entirely digital creations of the author. They are an original conceptual art work created specifically for you, the reader. This reading is the only time they will constitute a work of art. If you are reading this again, I was lying when you read this before. If you will read this again I will be lying then. If you won't read this again, I am lying now. Enjoy the concept.

4.2 The Importance of Theory. Art theory had its origins in the works of Plato and Aristotle. At the time, aesthetics, philosophy, mathematics and the sciences were all part of a larger whole. One area in which theory can play an important role is in the relationship between artist and viewer. Theory teaches us how to look at a work and deal with it in the context of what makes the work good art or, for that matter, art at all. It is not the function of art to kowtow to prevailing aesthetic fashions; and it is not the function of good theory to protect them. The role and even the existence of an avant garde is open to debate, but, nevertheless, the nature of artistic practice is such that it can itself negate any attempts to formulate a definition by simply acting outside that definition. Hostility toward new movements in art is commonplace. The names Impressionism and Fauvism began as derogatory comments. Duchamp's readymades were not simply art because he called them that. They became art because he expanded the definition of art. Artists are not autonomous individuals who bring forth works from their own genius or madness; but they must exist within the culture of art.

Art is an open concept—a category that keeps expanding, and necessarily so. When one seeks expansion across disciplinary lines, posing a challenge to existing attitudes, one must understand what those attitudes are, as well as the theoretical position of the challenge. When math becomes art it becomes conceptual art because it is conceptual to begin with. The challenge is not an in-your-face confrontation with an existing establishment; that ground has already been broken. It is instead a gentle demand to be taken seriously.

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