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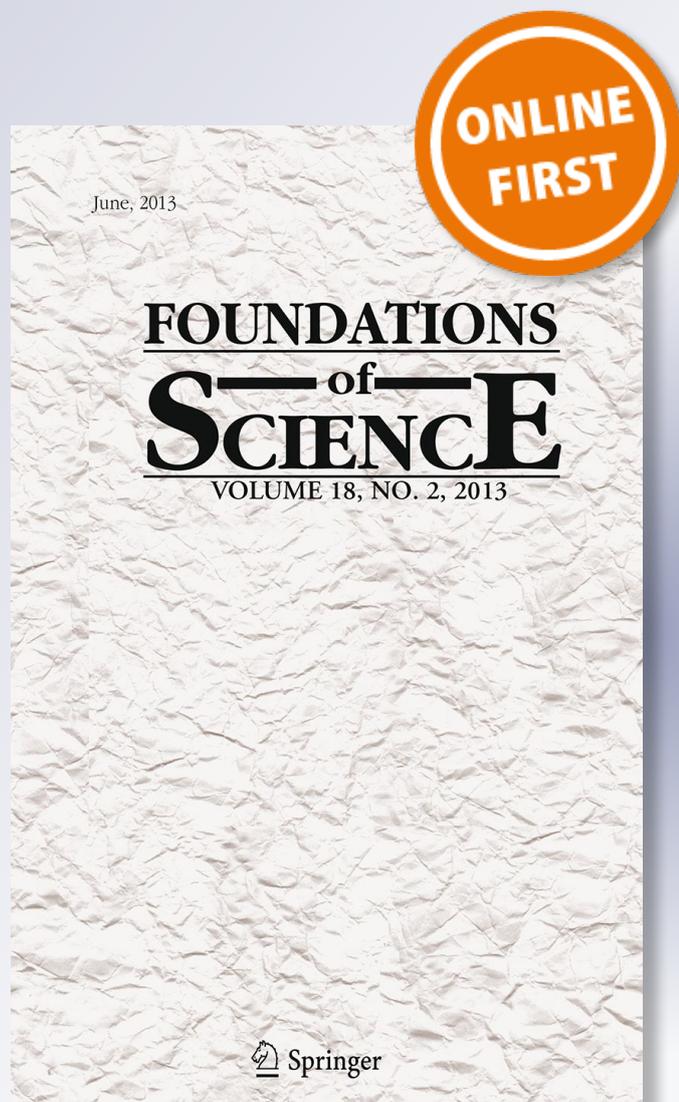
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Outline of a Theory of Scientific Aesthetics

Gustavo E. Romero¹

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Abstract I offer a theory of art that is based on science. I maintain that, as any other human activity, art can be studied with the tools of science. This does not mean that art is scientific, but aesthetics, the theory of art, can be formulated in accord with our scientific knowledge. I present elucidations of the concepts of aesthetic experience, art, work of art, artistic movement, and I discuss the ontological status of artworks from the point of view of scientific philosophy.

Keywords Aesthetics · Art · Ontology · Science

What art seeks to disturb is monotony of type, slavery of custom, tyranny of habit, and the reduction of man to the level of a machine.

Oscar Wilde¹

1 Introduction

We value objects and processes when we think or feel that they are good to us. And I maintain that they are good if they meet some need. The value has no independent existence, it cannot be found in the evaluated object because it is not there: it is in our brain. To state that something is good is a convenient way to express our need of it. Similarly, I claim that there are not beautiful things, there are just things deemed beautiful by some

¹ From: The Soul of Man under Socialism, *Fortnightly Review*, London, February 1891, p. 292.

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individuals in some context at some time. And things are considered beautiful because they produce a positive aesthetic experience in the individual. The task of aesthetics is to elucidate the nature of this experience, as well as the related concepts of aesthetic appreciation, art, work of art, and other meta-artistic ideas.

Art is the result of a human activity. As any product of what human beings do, art can be studied using the tools of science and philosophy. The outcome is *scientific aesthetics*. Art, certainly, is not scientific, but its investigation can be scientific. In what follows I will outline a theory of art that might be regarded as yet another branch of scientific philosophy.² I will start with the aesthetic experience that is the root of our appraisal of art.

2 Aesthetic Experience

Any account of aesthetic experiences has to address at least the following two questions: what it means for x to be an experience; and what it means for an experience to be aesthetic.

As any other human experience, the aesthetic experiences are processes taking place in the brain. These processes are triggered by interactions with an object (either artwork or a natural item) and depend on the objective properties of the object, the art-related knowledge of the individual, his or her emotional and pragmatic state, the ambient conditions, and the disposition of the subject. Other factors might be revealed by further neurological research based on functional magnetic resonance, magnetoencephalography, and electroencephalography performed while a subject is exposed to different types of artworks and objects of aesthetic appreciation. So far, it seems that the aesthetic experience involves the activation of sensorimotor areas of the brain along with core emotion centers, and reward-related centers (e.g. Di Dio and Gallese 2009; Brattico and Pearce 2013). The aesthetic experience seems to be a multilevel and complex process that exceeds the mere cognitive and sensorial analysis of artworks and relies upon visceromotor and somatomotor resonances in the beholder with major emotional centers, such as the insula and the amygdala, involved. The nature and depth of the experience depends strongly on the knowledge, training, and life-style of the subject, along with the external physical conditions (environment, illumination, ambient temperature). The aesthetic experience, then, emerges from the relationships among a sentient subject, an object, and the context in which they are embedded (Langer 2016).

The concepts of aesthetic experiences and aesthetic values are linked to each other by means of the following logical necessity (Dorsch 2000):

An experience of an object is aesthetic if and only if it ascribes a value to the object, and that value is aesthetic.

Any person unable to have aesthetic experiences will be indifferent to aesthetic judgments. Beauty is not found, it is experienced.

² I focus on theoretical aspects of scientific aesthetics. Experimental aesthetics deals with psychological research of artistic appreciation and it is not discussed here. The results of experimental research, however, are essential to test the theoretical concepts I introduce. See, for instance, Berlyne (1971) and Funch (1999).

3 Beauty

The aesthetic appreciation of different types of objects leads to aesthetic judgements. We say that an object, event, or process is *beautiful* iff it produces in us a particular kind of positive aesthetic experience. An experience is said positive if, under ideal conditions, makes the subject feel good and creates a desire to continue or repeat the experience. Specifically,

Definition An item a is aesthetically valuable in its aspect b for organism c in the circumstance d , and in the light of the body of knowledge f iff a produces a positive aesthetic experience in c .

I notice that an individual might have a positive aesthetic experience but the cause might not be deemed as beautiful. For instance, some objects might cause disgust or even repulsion, but nevertheless they might trigger cognitive and other brain processes regarded as aesthetically valuable and positive by the individual.³ So, the relation between positive aesthetic experiences and beauty is not a one-to-one relationship. Beauty is just a subset of all possible aesthetically positive experiences for an individual. The distinctive characteristics of the elements of the subset is that they induce an experience that is not only deemed positive, but delectable for the subject.

Aesthetic judgments involve relations of the form $Vabcd \dots n$. If we succeed in quantifying aesthetic values, the relation becomes a function from n -tuples of objects to numbers. For example: $V(a, b, c, d, u) = v$, where u is a suitable unit, and v the numerical value c attributes to a in its aspect b , on the basis of a knowledge f and in the stance d .

The general form of a real function representing aesthetic values is $V : A \times B \times \dots \times N \times U \rightarrow \mathfrak{R}$, where A is a collection of objects, B a collection of individuals, and the remaining factors in the Cartesian product, up to N , may be collections of things, properties, states, or processes, whereas U is a set of units, and \mathfrak{R} is the set of real numbers. As it occurs in ethics, quantifiable aesthetic values are exceptional (see Bunge 1989). Usually, only art critics and aestheticists care for doing such quantitative assignment. Partitions of the set B caused by different background knowledge or differences in conditions and other variables explain differences in value attribution by different critics to the same objects.

Beauty is simply the set \mathcal{B} of all objects deemed beautiful by an individual b , under conditions c , at a given instant t . The intersection of \mathcal{B}_i for objects of class x in a group G of individuals $i = 1, \dots, n$ in a society C is the *ideal of beauty* of x in that group.

Not only artworks can be aesthetically valuable. Landscapes, human faces, natural objects, animals, technological artifacts, scientific theories, and many other items can be regarded objects of beauty as well.

4 Art and Artworks

'Art' is a polysemous word with multiple referents. It is used for referring to artworks, but also to describe the activity of artists, the evaluation of works of art, their distribution, exhibition, and more. Many of these activities are associated with institutions, foundations, universities, schools, and commercial organizations. The concept of art is clearly multi-leveled and complex. Attempts to find necessary and sufficient conditions for any x to be

³ Examples include Alexandrian sculpture, French realist, naturalist, and decadentist literature, anti-war novels written in the 1920s by some outstanding French, German, and Austrian writers, whose main aim was to provoke revulsion, not pleasure, and much of contemporary plastic arts, among many other examples.

'art' are usually deficient because of the huge variety of activities that are considered as art (music, dancing, photography, sculpture, painting, drawing, cinema, drama, poetry, and so on). Moreover, within each specific art, many different movements, sometimes even opposed in both method and content, can be identified. Finding common elements is achieved only at the price of oversimplifications in such a way that counterexamples are always found (see, e.g., Meskin 2008; Davies 2013).

I think that the best approach to a definition of art is to start observing the kind of activities that we consider art, finding their more salient features, and then proceed to formulate a tentative characterization. The definition that I will offer, therefore, is provisional, descriptive, and perfectible. It should be improved to fit the facts, if necessary. This is the same approach we have adopted with other complex human products as science and technology. For similar views see Langer (2016).

First of all, let me remark that whatever art is, it is the result of human activity. These activities involve artists, i.e. persons with special training and skills that can create artifacts (both material and conceptual) that are judged as artistic by other people, including experts and at least some public. A work of art may be not recognized as such by part of the public and even it might be rejected by some experts. This sometimes leads to the formation of different schools and artistic movements. Since movements are more homogeneous than art in general, I will attempt at a characterization of the former first.

A specific art movement A_i can be represented by 11 components as:

$$A_i = \langle C_i, S, D_i, F_i, O_i, B_i, T_i, M_i, E_i, P_i, V \rangle, \quad (1)$$

where C_i is a community of artists. These are individuals that can design and construct artificial objects (either conceptual or material) called artworks or perform representations of works of art. S is a society that hosts (or at least is not hostile to) the members of C_i . D_i is the set of artworks. F_i is the set of material resources accesible to the members of C_i for creating, exhibit, and trade their works or execute performances (it includes workshops, theatres, art galleries, museums, etc). O_i is the set of artistic goals of the members of C_i . B_i is the total knowledge available to individuals in C_i to achieve their goals. T_i is the specific technical means available to those in C_i (it includes musical instruments, writing equipments, film industry, painting technology, and so on). M_i is the collection of rules, prescriptions, conventions, and instructions adopted by the members of C_i in connection with the movement A_i . E_i is the set of experts that make aesthetically sound judgments about objects in D_i in accordance with the rules of M_i . P_i is a collection of individuals that are exposed to the effects of the artworks created by the artists of C_i (the 'public'). V is the value system (axiology) adopted by the persons of C_i , which is based on the ethics shared by the society S .

Some comments are in order. An artistic movement is a material social system according to our characterization. Artistic movements can interact with other sub-systems of a society and play an active role shaping historical processes. Artists, critics, and public in general are linked by complex relations that go beyond the mere production and passive perception of artworks. Artistic ideas can pervade influential groups in a society and may help to shape the worldview of large social systems in some historical periods, as it was the case of Romanticism. Romanticism was an artistic, literary, and musical movement that originated in Europe toward the end of the 18th century as a reaction to the Enlightenment and the Classicism in the arts. It affected most aspects of intellectual life. Even scientists were influenced by versions of the *Naturphilosophie* of Johann Gottlieb Fichte, which would lead to German idealism and Hegel. Hegel in turn had a strong impact on Engels and

Marx, with the subsequent social and historic implications. Another prominent example of an art movement with global impact is the Renaissance, which was a broad cultural movement that exceeded the arts and affected every aspect of human society.

As any material system, art movements evolve with time. Hence, strictly speaking, the components of the proposed representation of art systems are sets only at a fix moment t . Otherwise, they are collections of individuals and not formal sets.

The existence of a group of experts is important for the emergence, consolidation, production, distribution, and general dynamics of an artistic movement. Experts play an important role in the legitimation of artists and their works. They are essential to evaluate, distribute, exhibit, and foster works of arts. Experts are (or should be) well-aware of the artistic conventions M_i and hence help in the self-regulation of art movements. Notice that the experts may be institutions besides individuals. In the case of extremely innovative artists whose conceptions and creations are not recognized as art by most of the public, experts usually make a decisive contribution to the consolidation or rejection of the new trends.

The group of individuals called 'the public' is the ultimate addressee of artworks. A number of them are expected to have aesthetic experiences when confronted with the works of arts. In the limiting case the set P_i has only one member: the artist. If the public is formed only by the artist and no expert ever recognizes the artistic nature of the artifact, then it cannot be objectively claimed that the artifact is an artwork. It will be only claimed as a piece of art by the 'artist' and his or her claim will remain entirely subjective.

The set of conventions and rules M_i regulate and guide the production of artworks. Usually these conventions are not explicit, so part of the task of the experts is to elucidate them. Since rules are conventional, exceptional authors can break them with various results. When the outcome of these experiments leads to new aesthetic experiences in a significant group of people, a new movement with new conventions emerges.

Work of arts are artifacts, i.e. human constructions (see next section). They can be material, such as paintings and sculptures, or conceptual as literary works, music, or stage plays. Conceptual artwork includes fictional work such as novels, and performances as live exhibitions, drama representations, etc. All artistic works are created with some goal (O_i) by the artist. The goal is related to the kind of aesthetic experience the artist seeks to arise in the public. These experiences are not necessarily positive, in the sense that some artists might look for producing anxiety, concern, even horror in their public within a valid aesthetic context (e.g. a movie).

From our characterization of an artistic movement it is clear that aesthetic statements and judgments can be perfectly objective but they are always relative to a certain aesthetic valuation system, which is conventional. That is, there are no aesthetic properties of artworks; we should assign an aesthetic value to the attributes of a certain artifact relative to an often implicit system of valuation. Of course, it would be preferable if these value systems were formulated in a clear and consistent way and available to public scrutiny. It is the task of aesthetic research to endow each art movement of a well-defined set of conventions in order to make possible objective and contrastable statements of value. This is the only way to discuss things such as the literary value of a poem or the cultural importance of a film. The same cultural product can have different objective aesthetic values regarding different valuation systems. If these are stated explicitly together with the valuation, then objective communication on aesthetic issues is possible. A meta-aesthetics should then be developed in order to offer selection criteria among the different aesthetic systems.

Once we are in possession of a tentative definition of art movement, we can define art as the set of all art movements.

$$\mathcal{A} = \{x/x = A_i, i = 1, \dots, n\}.$$

Then, art is a concept, not a material system, at least in the aesthetic theory I am presenting here. The study of art is the study of art systems, i.e. artistic movements. Each movement has its own specific features, with its artworks, rules and conventions, public, experts, etc. What they share is the basic structure defined through expression (1) above.

5 The Ontology of Art

What kind of entities should exist in order to legitimately say that there is art in a given society? If the answer includes 'works of art', then what sort of entities are works of art? Are they physical objects, ideal kinds, imaginary entities, or something else? What is common among such disparate objects as a stage performance, a novel, a symphony, and a painting? How many ontological types of works of art there are? These are the central questions of the ontology of art. They are not easy questions, as the surprisingly large number of views on possible answers shows (see Thomasson 2004 for a review).

We may start considering the reference class of our concept of art given by expression (1). The collection of arguments of the predicates that appear in our characterization of art movement (and hence in that of art) includes people (artists, experts, and critics), works of arts, material objects such as instruments, cameras, and dresses, conceptual constructions as rules, axiological systems and conventions, a society, and brain processes such as ideation, knowledge, and volitional acts. If we accept that the ontology of a concept is its reference class, then all these items integrate the ontology of art. Most authors, however, focus only on artworks.

The traditional views on the ontological nature of artworks fall in three broad groups. Those who think that works of art are essentially physical objects (e.g. Wollheim 1980), those who think of artworks as mental or imaginary (e.g. Collingwood 1958; Sartre 1966), and those who see them as abstract entities (e.g. Currie 1989). As noted by Thomasson (1999, 2004), these views are at odds with common sense beliefs and usual practices related to the arts. In particular, contrary to the traditional conception of abstract entities, works of art come into existence at definite moments (we can say, for instance, that Ludwig van Beethoven's Piano Sonata No. 8 in C minor, Op. 13, commonly known as Sonata Pathétique, was written in 1798) and they exist only on planet Earth. But contrary to pure physical objects, they might exist solely as brain processes (I think here in "The Secret Miracle", a short story by Jorge Luis Borges⁴). Thomasson (1999) proposes, and I subscribe, that works of art are *cultural artifacts*, i.e. intentional constructions (either material or conceptual) created by human beings with the goal of producing aesthetic experiences.

⁴ The main character of the story is a playwright named Jaromir Hladík, who is living in Prague when the city is occupied by the Nazis during World War II. Hladík is arrested and charged with being Jewish as well as opposing the Anschluss, and sentenced to die by firing squad. During his execution God allows him a whole year of subjective time while everything else, including his body, remains motionless. Working from memory, Hladík mentally writes, expands, and edits a play, the artwork of his life, shaping every detail to his full satisfaction. Finally, after a year of labor, he completes the piece; only a single epithet is left to be written, which he chooses: time begins again and the fire from the rifles of the squad kills him. No one else will ever know that he finished his work and created the play.

Hence, artworks are not independent of humans in the sense that they are created by intentional activities, and exist only as long as socio-cultural actors are aware of them. Works of music and literature, for instance, are created by the authors at a certain time and context, and then reproduced by a variety of means, including printed books, pdf files, audio books, sheet-musics, performances, recitations, etc. The artwork will last till the last score, recording, printing or memory of it be obliterated or forgotten.

In short, the existence of art is possible only if a number of material entities interact. Among them, we can mention artists that create artworks, public, and experts. The creation and interaction processes also require material means such as theatres, paintings, art galleries, books, musical instruments, and much more. Works of arts are human products, cultural artifacts, that once created can exist independently of its creator, but not of all human beings. Art needs both the intention of the artist and the sensibility of the public in order to exist.

6 Three Examples

It might be useful to trace parallels among different types of objects of aesthetic appreciation in the light of the theory I have presented. In this section I discuss three cases: a universally recognized artwork such as Beethoven's Ninth Symphony, a modern masterpiece of cinema by Martin Scorsese, and a major scientific theory as Einstein's General Relativity. These examples will help to illustrate the applications of the theory.

Beethoven's Symphony No. 9 in D Minor, Op. 125 is one of the best-known works in classical music. It is almost universally considered by critics today as one of Beethoven's greatest pieces, and many consider it one of the greatest compositions in the Western musical canon.

The symphony is in four movements. The famous choral finale is Beethoven's musical representation of universal brotherhood. For this last chorus, Beethoven turned to a lengthy poem by Friedrich Schiller, the "Ode to Joy" (1785). Through this chorus, Beethoven expressed his deeply felt political vision based on the ideals of the Enlightenment. He was the first major composer to include vocals in a symphony.

The Presto finale opens with a dissonant and frantic passage that leads to a "recitative" (so marked in the score) for the cellos and basses. Fragments from the previous three movements pass in review—a few measures of the opening theme of each—but are rejected by the strings. After this strange, extended recitative comes the aria: the "Ode to Joy" melody to which later will be added words. After some seven minutes the movement starts over again. The chorus and four vocal soloists take up then the "joy" theme, which undergoes a continuing series of variations. The music reaches a climax with a new theme: "Be embraced, ye millions! Brothers, above the starry canopy there must dwell a loving Father", which is later combined in counterpoint with the joy theme and eventually builds to a frenzied coda.

This movement finds today almost universal admiration. However, when it was first performed was received with perplexity, disdain, and in some cases even repulsion. Let us see a few examples (Slonimsky 2000).

The fourth movement is, in my opinion, so monstrous and tasteless and, in its grasp of Schiller's 'Ode', so trivial that I cannot understand how a genius like Beethoven could have written it. I find in it another proof of what I had already noted in Vienna, that Beethoven was wanting in aesthetic feeling and in a sense of the beautiful.

—composer Louis Spohr, a contemporary of Beethoven.

Beethoven, this extraordinary genius, was completely deaf for nearly the last ten years of his life, during which his compositions have partaken of the most incomprehensible wildness. His imagination seems to have fed upon the ruins of his sensitive organs.

—William Gardiner, *The Music of Nature*, London 1837.

The alpha and omega is Beethoven's Ninth Symphony, marvellous in the first three movements, very badly set in the last. No one will ever approach the sublimity of the first movement, but it will be an easy task to write as badly for voices as in the last movement.

—Giuseppe Verdi, 1878.

Even towards the *fin de siècle*, we find criticisms as this one:

We heard lately in Boston the Ninth Symphony of Beethoven. The performance was technically most admirable...But is not worship paid this Symphony mere fetishism? Is not the famous Scherzo insufferably long-winded? The Finale...is to me for the most part dull and ugly...I admit the grandeur of the passage 'und der Cherub steht vor Gott' and the effect of 'Seid umschlungen Millionen!' But oh, the pages of stupid and hopelessly vulgar music! The unspeakable cheapness of the chief tune, 'Freude, Freude!'

—Philip Hale, *Musical Record*, Boston, June 1, 1899.

These reactions can be well understood in the context of the theory exposed in this article. Beethoven's Ninth appeared when the author was already well recognized, and the boundaries of the symphonic style were well delimited. Beethoven, however, pushed the accepted limits and most critics were unable to adapt immediately their standards to the new composition. This explains the negative reactions to the last movement. The strong emotional effects of the Ninth Symphony on the public, nevertheless, provoked sympathy and enthusiasm among those who were not so constrained by the conventions of already existing art movements. As time went by, the conventions evolved, and the opinion of critics softened, and eventually reversed. This illustrates our hypothesis that aesthetic values (as well as the other components of an art movement) evolve with time and also with the state of those who appreciate art. One and the same work of art was received diversely according to the compromise of the audience with a set of conventions and their musical and cultural background.

A completely different example of a controversial artwork is the 1976 film *Taxi Driver*, directed by Martin Scorsese and written by Paul Schrader. Set in New York City the film stars Robert De Niro, and features Jodie Foster, Harvey Keitel, Cybill Shepherd, Peter Boyle, and Albert Brooks.

Travis Bickle (Robert De Niro), a loner who comes from somewhere else, drives a Manhattan cab at night. In the day he sleeps in short naps, pops pills to calm down, swigs peach brandy, which he sometimes pours on his breakfast cereal, and goes to porn films to

relax. Haunting the streets nightly, growing increasingly detached from reality as he dreams of cleaning up the filthy city, Travis looks for some kind of escape. He meets a pretty campaign worker named Betsy (Cybill Shepherd) and makes some attempts towards establishing a relationship, failing miserably. He then becomes obsessed with the idea of saving the world, first plotting to assassinate a presidential candidate, then directing his attention toward rescuing 12-year-old prostitute Iris (Jodie Foster).

In the film's bloody climax, Bickle attacks a brothel, killing Iris's pimp Sport (Harvey Keitel), a bouncer, and a local gangster that was with Iris. When armed police officers storm the room, they find Travis covered in blood, miming a pistol with his hand and committing mock suicide.

After the shootout, Martin Scorsese gives us an overhead shot of the brothel. As the camera slowly pans down the hallway and into the street, we see the blood-stained walls, the bodies slumped on the floor, and the curious spectators gathered outside. It is a recap of Travis's bloody rampage. The scene then cuts to Travis's apartment where the walls are now covered with newspaper clippings celebrating Travis as a hero for killing a Mafia boss.

As the camera pans across the wall, we hear the voice of Iris's father, thanking the taxi driver for saving his daughter. After the monologue, we watch as Travis picks up Betsy in his cab and drives her home. During their short talk, Betsy almost expresses remorse for rejecting Travis. When she steps out of the cab, Bickle refuses to let her pay for the ride and drives off into the night, leaving Betsy behind. In the last seconds of the film, Travis looks into his rearview mirror and sees his own wild eyes looking back. Travis adjusts his mirror and looks away from his reflection.

Contrary to symphonies, movies are not always considered as artworks. Some films are produced only for entertainment or commercial purposes without any claim or pretense of artistic content (many commercials, pornographic films, and cheap movies, for instance). Other films, although conceived by their authors as some kind of art result so bad in any aspect that critics and public alike dismiss them as failed attempts. This was certainly not the case of *Taxi Driver*. The technical quality of the movie, the photography, music, the script, and the performances were immediately recognized by critics as outstanding. The value of the film, however, was initially questioned by many. When the film premiered at Cannes, the reaction of the public was mixed: "Half the audience was on its feet cheering", recalls producer Michael Phillips. "The other half was booing.". This might be due to the realistic depiction of violence and the difficult subject of the film. The topic of child prostitution might also have offended some sensibilities. But the more experienced critics also expressed some disappointment.

Critics had the general inclination to reject the film because they were unable (or unwilling) to understand the implications of the ending. They thought that by the end Travis was rehabilitated. In taking literally the events in the last sequence of the movie, these reviewers assumed that the film adopts a traditional happy ending. But such a narrow-minded perception does not take into account Scorsese's elaborate staging of Travis's character flaws and questionable behavior.

From the point of view of the aesthetic theory under discussion here, we can say that the acceptance of the film as an artwork despite it would not be described as "beautiful" is related to the immediate recognition of other positive qualities that can produce an aesthetic experience in the audience. The film is perceived as a deep meditation into alienation and loneliness in modern society. It provides a unique view into the existential qualms of an individual that fails to make contact with his fellow human beings. Ebert (2004) comments:

The film can be seen as a series of his failed attempts to connect, every one of them hopelessly wrong. He asks a girl out on a date, and takes her to a porno movie. He sucks up to a political candidate, and ends by alarming him. He tries to make small talk with a Secret Service agent. He wants to befriend a child prostitute, but scares her away. He is so lonely that when he asks, "Who you talkin' to?" he is addressing himself in a mirror.

After a few minutes watching the movie we realize that we are in front of a masterful use of the technical tools of cinema. Slow motion, music, close-ups, camera movements, photography: all combine to suggest a subjective state. "One of Scorsese's greatest achievements in *Taxi Driver* is to take us inside Travis Bickle's point of view" (Ebert 2004). All these resources help to create an experience that sometimes might be very disturbing and distressful, but never fails to be aesthetic.

The differences in the appreciation of the overall value of the film might be related to the value system of the public and critics at the moment the picture first appeared. It was a time of moral tiredness, after Vietnam war and Watergate. Many people would dare venture into Travis's mind, but very few would gladly accept that he might triumph. For this type of moral sensibility Travis should have paid for his crimes, perhaps dying in the final shootout.

A few critics, however, were able to see beyond the prejudices of the moment. Pauline Kael was one of the first serious critics to take Scorsese's side in the debate. She wrote in the *New Yorker* (76-02-09) :

This film doesn't operate on the level of moral judgment of what Travis does. Rather, by drawing us into his vortex it makes us understand the psychic discharge of the quiet boys who go berserk. And it's a real slap in the face for us when we see Travis at the end looking pacified. He's got the rage out of his system—for the moment at least—and he's back at work, picking up passengers in front of St-Regis. It's not that he's cured but that the city is crazier than he is.

Scorsese and Schrader eventually confirmed this point of view (Thompson and Christie 1996). It is a much subtler and difficult-to-accept reading of the film. Travis becomes an idol to the very city he despises, the same place he wants the rains to wipe away. That doesn't say a lot for America's values. It took sometime for the critics to accept that view and digest the criticism it contains of the American society at large. The movie, nevertheless, made its way and today is almost universally acclaimed (99% of positive reviews in Rotten Tomatoes). This stresses my point that aesthetic statements and judgments can be perfectly objective although they always are relative to a certain valuation system. The values are neither explicit nor fixed; sometimes they depend on transient circumstances and always evolve with the people who profess them. The aesthetic phenomenon occurs in the interaction of the artwork and the individual, and is as mutable as the individual.

As a final example let us consider a human product that was not conceived as a work of art, but nevertheless has aesthetic qualities: Albert Einstein's theory of General Relativity. By 1907, Einstein was requested to write a review of his theory of Special Relativity. He took the opportunity to discuss how would be possible to generalize the theory to encompass accelerated physical systems. This naturally led him to discuss gravitation in the context of relativity. He realized that the equivalence principle should play an essential role in founding a general theory. This, in turn, implied that the new theory should be a theory of gravitation. After more than 7 years of work and several false steps, Einstein came to the new theory in November 1915 [see Renn et al. (2007) for a detailed account].

The central insight of General Relativity is the substitution of the gravitational field by curved spacetime. In doing this Einstein achieved not only a major conceptual simplification but also dramatically increased the predictive power of classical physics. The central dynamical equations of the new theory give a relation between geometric properties of spacetime (its curvature) and the properties of matter (energy density and momentum). Solving the equations, it is possible to obtain the metric of spacetime, and then the equations of motion for test particles. If the curvature is different from zero, trajectories depart from straight lines. The theory solves the problem of action at distance, present in Newton's theory of gravity, explains the perihelion shift of Mercury, and predicts many new effects such as gravitational lensing, the gravitational redshift of radiation, and gravitational waves.

Although the primary motivation for developing General Relativity was scientific, it is well-known that aesthetic concerns were important to Einstein (e.g. Pais 1982). And the final result of his endeavours has been unanimously considered by theoretical physicists as the most beautiful of all physical theories (e.g. Landau and Lifshitz 1971, p. 227). Even Einstein's contemporaries such as Lorentz and Weyl were of the same opinion. Lorentz, for instance, thought that the theory has the "highest degree of aesthetic merit" (Engler 2002). Dirac (1980) wrote about the "beauty and elegance" of General Relativity. Rutherford said that "The theory of relativity by Einstein, apart from any question of its validity, cannot but be regarded as a magnificent work of art" (Chandrasekhar 1984). And we might continue. Einstein himself wrote in November 1915, referring to his new theory: "Nobody who really grasped it can escape from its charm..." (Einstein 1915).

Physicists differ, nevertheless, about what features make of General Relativity an aesthetically valuable scientific theory. Among others, the following ingredients have been invoked to explain its aesthetic appeal (e.g. Chandrasekhar 1984; Chao 1997; Engler 2002 and 2005): simplicity, symmetry, unification strength, fundamentality, mathematical beauty, explanatory power, and logical completeness. It is indisputable that the theory has all these traits. From a system of just 10 non-linear second order differential equations it is possible, in principle, to calculate the evolution of any physical system whose energy-momentum is specified. Contrary to other theories, both the equations of motion for matter and the conservation laws can be obtained from Einstein's equations. The group of symmetries of the theory is simply the most general one: the group of all possible transformations among reference frames. The theory unifies the concepts of space and time, and eliminates gravitation, which is now understood as the effects of the curved geometry of spacetime. General Relativity is also truly fundamental, in the sense that it cannot be obtained in the limit of another theory, at least within classical physics. And nobody would deny that the mathematical formalism, developed by Riemann and Levi-Civita, has all the aesthetic attributes that mathematicians confer to their most cherished creations. The non-linearity of the equations results in an extraordinary variety of predictions that can be derived from different sets of initial and boundary conditions. Finally, the theory is both logically and semantically closed, without strongly controversial issues as those that are associated, for example, with quantum mechanics.

Our aesthetic theory does not specify the set of conditions that make of a certain object not only aesthetically valuable but also beautiful, since such a set depends on the kind of object. A scientific theory presenting all the enumerated features in the highest degree seems to be a good candidate to "probably the most beautiful of all existing theories" (to use Pauli's words—see Chandrasekhar 1984). The conjunction of all these desirable characteristics might very well be expected to induce a very pleasurable aesthetic experience in those capable to understand the theory.

Perhaps there is an additional aspect of General Relativity that produces the maximum aesthetic impact. I venture that this aspect is its *perfection*. In words of Einstein:

A modification of it [GR] seems impossible without destruction of the whole.

—Einstein (Einstein 1950, p. 85).

I defined a certain object as *perfect* if any change produces a diminution in it. In this sense, General Relativity is on par with the previous two examples of artworks: hardly any change might improve the overall aesthetic experience they spark in us.

7 Concluding Remarks

Aesthetic experiences are a type of brain processes that occur in certain (evolved) organisms. They depend both on the external stimulus produced by an object (either natural or artificial) and the state of the organism. If the experience is positive, the organism deems the object as aesthetically valuable. In some cases, where specific criteria are met, the object might be considered as beautiful. Aesthetic experiences are the roots of aesthetic valuations. There are not beautiful things or events in themselves: aesthetic values, as all values, are fictions attributed to some objects by some organisms in a particular state. Artistic movements are material socio-cultural systems that include artists, experts, critics, and the many material and conceptual items associated with their specific activities. Art is simply the class of all art movements. Each of these movements includes some conventions with respect to which artistic judgements are done. Work of arts are cultural artifacts, i.e. human constructions produced in a cultural context within a society, whose goal is to induce some kind of aesthetic experience in the beholder. Artworks can be material, such as paintings and sculptures, conceptual such as literary works, music, or stage plays, or mixed, as a stage performance. Aesthetics is the philosophical study of art. Art is not scientific, but aesthetics can become so.

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