Gonçalves, Clara Germana Ramalho Moutinho

Creativity and beauty in art and science today : a basis for discussion of a possible future architecture

Resumo Considering that, throughout history, architecture has always been seen as being somewhere between art and science, and that the concepts of art and science have been subject to changing interpretations in time, this article explores the idea of how a theoretical discussion on the relationship between the arts and sciences – focusing specifically on creativity and beauty in both – might help in, and also be a justification for, reflecting, on the one hand, on the possible integration of architec...

Creativity and beauty in art and science today: a basis for discussion of a possible future architecture

Clara Germana GONÇALVES
CITAD, Lusíada University, Portugal / ISMAT, Portimão, Portugal
claramoutinho@gmail.com

This is an Accepted Manuscript of a book chapter published by Routledge/CRC Press in *Intelligence, Creativity and Fantasy: Proceedings of the 5th International Multidisciplinary Congress (PHI 2019)*, October 7-9, 2019, Paris, France, in 2019, available online:
https://www.taylorfrancis.com/books/edit/10.1201/9780429297755/intelligence-creativityfantasy-m%C3%A1rio-ming-kong-maria-ros%C3%A1rio-monteiro-maria-jo%C3%A3o-pereiraneto

Creativity and beauty in art and science today: a basis for discussion of a possible future architecture

Clara Germana GONÇALVES[1]
(1) CITAD, Lusíada University, Lisboa, Portugal / ISMAT, Portimão, Portugal
claramoutinho@gmail.com
ORCID: 0000-0002-1236-5803

Abstract

Considering that, throughout history, architecture has always been seen as being somewhere between art and science, and that the concepts of art and science have been subject to changing interpretations in time, this article explores the idea of how a theoretical discussion on the relationship between the arts and sciences – focusing specifically on creativity and beauty in both – might help in, and also be a justification for, reflecting, on the one hand, on the possible integration of architectural reasoning and/or design in and from other areas, and, on the other, on a non-human architecture (of a micro and macro scale) or not subject to gravity.

Keywords: future of architecture, art, science, creativity, beauty

1. Introduction

Architecture has always been dependent on the fate of art: at times, and indeed almost always because it was faithful to art, and at other times, because it wanted to escape art, a desire shown by the more orthodox side of the Modern Movement. But architecture has also been shaped by the fate of science: from the belief in the architect-Demiurge to the rejection of a scientific approach to doing things to the detriment of artistic freedom. Architecture has always gravitated between art and science and between the union and distance between them. The current tendency towards the re-approximation of art and science is the starting point for the discussion on architecture that is proposed herein.

Interdisciplinary dialogue would appear to be something essential, as specialisation tends to create isolated areas of knowledge, annul the relationships between the various disciplines and encourage the discounting of areas whose autonomy is not clear. In this respect, architecture can have a dual role, as its particular nature is non-specialized: interdisciplinary discussion also appears to be fundamental to its inner core, making architecture a privileged vehicle for such a discussion.

C. P. Snow, who has been frequently cited for the ideas he exposed in his seminal essay *Two Cultures* (1959) is still a reference figure in this discussion. For instance, the article "Creativity in art and science: are there two cultures?" (Andreasen and Ramchandran, 2012), which discusses creativity in individuals from both the arts and the sciences, cites him as follows (p. 50):

> In our society (that is, advanced western society) we have lost even the pretense of a common culture. Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern. This is serious for our creative, intellectual and, above all, our normal life. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action…

2. Art and science

It is very common to find people for whom the study of mathematics and art is equally exciting. They feel the same sense of transcendence when studying mathematics or art. Whether it be from the point of view of

the ideas, the process or the results. The pleasure of mathematics is also the pleasure of using its language, which is equal to the pleasure of looking at a colour, or touching paints, even if in their raw and unworked form.

With regard to architecture, it is worth remembering that whilst, on the one hand, in the nineteenth century architecture was deeply identified with the *beaux arts*, on the other hand, the idea that architecture is a science (with, according to that very definition, each part of a building integrated into one and the same system of mathematical ratios), may be considered, according to Wittkower (1998, p. 104), the basic position of Renaissance architecture.

Continuing this line of argument, Pelletier and Perez-Gomez (1994, p. 4) clarify:

> The reduction of the fine arts to a morally inconsequential aesthetic formalism is not an absolute paradigm but rather an historical event related to the glorification of scientific reason during the eighteenth century. Believing that positive science is capable of disclosing absolute truth – a belief whose roots were indeed theological – the rationalists implicitly relegated art (and "non-scientific" architecture) to a marginal, illegitimate zone.

Both aspects can be contextualized through the idea proposed by Alistair C. Crombie (1986, cited in Garfield, 1989, p. 56) that the period in which Galileo lived, is one that mediated between the time of the "rational constructive artist" (personified by Michelangelo) and the "rational experimental scientist " (personified by Newton).

And, if on the one hand, architecture has always oscillated between art and science, on the other, art and science are seen alternately as two worlds, at times irreconcilable, and sometimes very close and, in certain aspects, practically indistinct. Several authors reference this approach, which can be seen from different points of view, often contradicting the current common-ground viewpoint. Federico Mayor (2001, p. 5) argues that "[o]ccasionally, when science reaches beyond its frontiers, it merges with philosophy. Likewise, art can be dematerialized – boiled down to pure ideas." In addition, it can be argued that, contrary to the "romantic" idea of the "inspired" artist, which is still very present in the current imaginary, "[a]rtists exercise the same self-discipline and rigour as scientists." (Mayor, 2001, p. 5). Or, in the words of Ortega y Gasset (1963, p. 391), referring to poetry:

> [I]n one of its dimensions, poetry is an investigation, and it discovers facts as positive as those habitually discovered in scientific research.[1]

In retrospect, it is also important to remember that the Greek *téchné* and the Latin *ars* refer, at the origin of Western culture, to any activity that implies previous knowledge and experience, or an activity that implies a skill that can be exercised in apprenticeship. And Eliane Strosberg (2001, p. 29) explains how the word "scientist" first emerged in Britain only in 1863. It is indicative of the approximation which, despite the given hierarchies, existed between the various disciplines.

One particularly captivating fact is that we can say that many of the attributes traditionally associated with art are now the prerogative of science. In the words of Siân Ede (2005, p. 1):

> Scientists weave incredible stories, invent extraordinary hypotheses and ask difficult questions about the meaning of life. They have insights into the working of our bodies and minds which challenge the way we construct our identities and selves. They create visual images, models and scenarios that are gruesome, baffling and beguiling. They say and do things that are ethically and politically challenging and shocking. Is science the new art?

Early in the twentieth century, in his classic *Abstraction and Empathy* (1907), in which he reflected on the (apparent?) paradoxical romantic world, Wilhelm Worringer, evoking Novalis' (1772-1801) earlier thoughts on the subject, argues for the possibility of mathematics being an art form (1997, p. 19):

> We frequently find the, at first sight,

[1] [Free translation. Or: "[e]n una de sus dimensiones la poesía es investigación y descubre hechos tan positivos como los habituales en la explotación científica."]

> astonishing idea put forward by modern art theoreticians that mathematics is the highest art form; indeed it is significant that it is precisely Romantic theory which, in its artistic programmes, has come to this seemingly paradoxical verdict, which is in such contradiction to the customary nebulous feeling for art. Yet no one will venture to assert that, for instance, Novalis, the foremost champion of this lofty view of mathematics and the originator of the dicta, 'The life of the gods is mathematics', 'Pure mathematics is religion', was not an artist through and through.

And further, on the relationship between art and mathematics, Paul Valéry (1871-1945) is an example of an author for whom both "cultures" (to use C. P. Snow's term) were most definitely not incompatible. Alongside poetry, he studied mathematics for almost all his life. To him, "[s]cience and art are crude names, in rough opposition. To be true, they are inseparable …". He goes on to reflect: "I cannot clearly see the differences between the two, being placed naturally in a situation where I deal only with works reflecting thinking matters." (cited in Strosberg, 2001, p. 14) In reality, the difference lies in the gradation of the degree of certainty affecting both:

> An outstanding difference between the sciences and the arts is that the former must aim at results that are either certain or immensely probable, whereas the latter can only hope for results of an unknown probability. (Valéry, 1977, p. 39)

Graham Farmelo (2003a, p. xiv) compares a work of art with an equation:

> Much like a work of art, a beautiful equation has among its attributes much more than attractiveness – it will have universality, simplicity, inevitability and an elemental power.

Discussing the boundaries between these important traditional areas of knowledge is paramount when a discussion on the current epistemological structure is proposed as a basis for discussing the future of architecture.

3. Creativity

"Creativity is a prized feature of the human mind, but prizes can coexist with puzzlement." This statement from Margaret A. Boden (1996b, p. 1) is very eloquent. Many questions arise when discussing creativity. What is it? What is the relationship between novelty and creativity? Is the creative process the same in art and science? This last question is of the utmost importance for the present discussion, as is the idea of two separate worlds: that of the arts and that of the sciences.

Margaret A. Boden concludes her essay on creativity (1996a, p. 289) with the following words:

> Creativity is not a separate "faculty," but an aspect of general intelligence – which involves many kinds of thought process. (...) The study of creativity is inescapably interdisciplinary.

These are two fundamental ideas which are shared with many other authors.

Studies in the neurosciences indicate that perhaps these areas, which are commonly considered to be different, are not so different after all, as proposed by Andreasen and Ramchandran (2012, p. 50):

> For many lay people, the word "creative" evokes images of novelists, poets, composers, and visual artists. If prompted, they would acknowledge the creativity of mathematician/physicists such as Einstein or inventors such as Thomas Edison, but there is a general tendency to assume that creativity is more associated with the arts than the sciences.

And whilst it is art that is essentially, or traditionally, associated with creativity, it is also pertinent to recall that the concept of creativity is a very recent one.

The notion of creativity as inventive and free achieving or accomplishing only gains true expression in the philosophy of art from the nineteenth century and the Romantic revolution onwards. At the dawn of Western culture, the term *poiein* refers to the reproduction of things existing in nature. Any new creation or originality was excluded, for art was governed by strict rules (such as canons or rules of proportion). In accordance with this idea, the Greek Demiurge emerges as an ordainer, not a creator. In the eighteenth century, the concept of creativity began to emerge more frequently and was increasingly associated with the concept of imagination. And in the nineteenth century,

in contrast to the preceding centuries, art became practically synonymous with creativity. But after the great Romantic liberation, in reacting to the progressive banalization of the idea of creativity, the new currents in artistic expression, with few exceptions (such as Surrealism or Expressionism), failed to underline the value of enthusiasm and giving free rein to the fantasy, as had been part and parcel of Romanticism. (Carchia, 2009, pp. 83-85; Tatarkiewicz, pp. 248-249)

The discussion of the term "creator" is typical of, and in line with, the debate of this issue. For a thousand years of academic study, the term did not even exist, not even in theology; in the following thousand years, it has existed, but only in reference to God. Indeed, in the nineteenth century, the term "creator" was incorporated into the sphere of art, becoming exclusively used in the said sphere, with "creator" being used very much as a synonym for the artist. One must, however, except the case of poetry which, since Greek antiquity, has had a special status. So much so that imagination and inspiration were, in classical Greece, ideas associated only with poetry. According to Tatarkiewicz, it was the Pole Maciej Kazimierz Sarbiewski (1595-1640) who, referring to poetry, used for the first time the word "creator": in his words, the poet not only "invents" (*confingit*), but "*creates anew*" (*de novo creat*); he even adds that the poet creates "in the manner of God" (*instar Dei*). However, one must stress again, this privilege belonged only to poetry; the other arts imitated and copied. From the nineteenth century onwards, creative as an adjective, and creative as a noun, became part of the new lexicon. And "creator" often referred to the artist or poet. One should also mention that what is now understood by creativity is different: the idea of *ex nihilo* disappears; creativity is now understood as the creation of new things and not the creation of things out of nothing (Tatarkiewicz, 1980, pp. 248-251, 282-288).

From the twentieth century on, the term "creator" began to be applied to all human culture (including the sciences, politics, technology). Today we use variants of the same root word with a similar meaning: creator, create, creative, creativity. Creativity is the central term. And Tatarkiewicz points out its double meaning: on the one hand as a process – in the mind of the creator – and on the other, (in the Polish language at least[2]) the product of that process. There is a significant difference between these two meanings, for we know the works but scarcely know the process (Tatarkiewicz, 1980, p. 251). The feature that distinguishes creativity in every field is novelty (in an activity or a work). Every instance of creativity implies *novelty*, although the inverse is not the case. (Tatarkiewicz, 1980, p. 257).

Tatarkiewicz (1980, p. 249) highlights the fact that, at the beginning of the twentieth century, when creativity in the sciences and nature increasingly became a theme of discussion, there was a transference to the sciences and nature, of concepts proper to art. One can cite as an example of this Matila Ghyka's (1881-1965) several studies which, despite their undoubtedly interesting approach to human and nature's proportions and structure, seem to be a case in which artistic proportions were (one might say) forced onto natural forms. And Tatarkiewicz (1980, pp. 249-250) presents further reflection that shows how the objectives of art and science can be confused or, at least, approximated:

> The point is that art and poetry have at least two basic values, both of which may be and have been its aim: on the one hand, the groping for the truth, the plumbing of nature, the discovery of rules, of the laws governing human behaviour – and on the other hand, creativity, the creation of new things that have not been before, of things that have been invented by man. In short, art and poetry have two watchwords: law, and creativity; or: rules, and freedom; or again: skill, and imagination. The history of the concept of creativity indicates that for a very long time, the first role was uppermost. History shows that for a long time it was not believed that both roles could be fulfilled simultaneously.

[2] This observation, included by the author, has intentionally been left in here for its relevancy.

Indeed, amongst various figures of acknowledged renown, Eugene Garfield cites A. L. Copley who was a scientist as well as an artist to testify to this proximity: "What is common to both art and science is the creative process and the synthetic thinking in both human endeavors" (1987, cited in Garfield, 1989, p. 54).

And art and science can come closer to each other by both the creative act and the desire to "surpass reality", as Federico Mayor (2001, p. 5) suggests:

> What is common to art and science? Creation. Or rather the drive that impels creativity. The thrill of the world and sound, of the color, lines and shapes of art. The temerity of the scientific hypothesis which extends beyond reality. What is the aim of a creative act in art or science? To surpass reality.

"To surpass reality." This phrase expresses succinctly one of the themes to be proposed herein as an object of study in architecture to be developed in the future: an architecture for scales other than the human scale.

Andreasen and Ramchandran (2012, p. 49) explain how they analysed "the relationship between creativity in the arts and the sciences" using "functional magnetic resonance imaging to explore the neural basis of creativity in a group of (...) individuals from both domains". And they conclude:

> This small group of "big C" [high levels of creativity] individuals includes a diverse group of artists and scientists. When the activations in the two groups are compared, the findings give no support for the notion that the artists and scientists represent 'two cultures'. Rather, they suggest that very gifted artists and scientists have association cortices that respond in similar ways.

It is also of interest here to discuss what is actually invented – let us call it pure human invention – i.e., what will be a real discovery. Even if the mechanisms for that discovery may be purely, or, fundamentally, human.

Roger Penrose (1990: 123-124) points out:

> How 'real' are the objects of the mathematician's world? From one point of view it seems that there can be nothing real about them all. Mathematical objects are just concepts; [...] Can they be other than mere arbitrary constructions of human mind? [...]. It is as though human though is, instead, being guided towards some external truth – a truth which has a reality of its own, and which is revealed only partially to any one of us.

Moreover, Penrose (1990, p. 125) argues that what, in science, usually has the status of human invention is not, in fact, invention it is in reality, a discovery. It is discovery, because if, in reality, the phenomenon exists, then the scientist does not invent it, they discover it. He goes on to illustrate this idea: "The Mandelbrot set is not an invention of the human mind: it was a discovery. Like Mount Everest, the Mandelbrot set is just there!"

"Is mathematics invention or discovery?" Penrose would argue for the second hypothesis, but he also states that "the matter is perhaps not quite so straightforward." In some cases, "the word 'invention' seems more appropriate than 'discovery'." Penrose explains both situations using, respectively, the expressions "works of man" and "works of God" (quotation marks from the original text). He goes on to explain that this fact is comparable to those that occur in the arts or engineering, and that: "great works of art are indeed 'closer to God' than are lesser ones". He quotes Jorge Luís Borges – "a famous poet is less of an inventor than a discoverer [...] – to express the idea that the greatest works of art reveal "eternal truths which have some kind of prior etherial [sic] existence". (Penrose, 1990, pp. 126-127)

Once more, the discourse is similar for both art and science.

4. Beauty

There is another aspect that seems to be of paramount importance when discussing science and art. That aspect is beauty. And whilst beauty may be an unappreciated expression in art today, scientists, on the contrary, feel free and happy to use it. And not without reflection. "Contemporary scientists often talk about 'beauty' and 'elegance'; artists hardly ever do." (Ede 2005, p. 1) This is the strong argument with which Siân Ede begins her book *Art and Science*. Moreover, she argues: today, "[scientists] use frequently a word that is scarcely ever heard in the arts. That word is 'beauty'." (Ede 2005,

p. 13)

Graham Farmelo (2003a, p. xv) writes on Einstein:

> The concept of beauty was especially important to Einstein, the twentieth century's quintessential aesthete. According to his elder son Hans, 'He had a character more like that of an artist than of a scientist as we usually think of them. For instance, the highest praise for a good theory or a good piece of work was not that it was correct nor that it was exact buy that it was beautiful'.

And Bertrand Russell (echoing Novalis?) passionately argues before him (1959, p. 60):

> Mathematics, rightly viewed, possesses not only truth, but supreme beauty – a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry.

We find a link in history. Copernicus (1473-1543) insisted on uniform circular movement in his heliocentric system while appealing to the aesthetic judgement of his fellow mathematicians: Ptolemaic system lacked beauty and unity. This was the reason for other Humanists to reject the work of the Scholastics (Bronovski and Mazlisch, 1988, p.129). Likewise, aesthetics judgment was present in Galileo:

> Galileo found Copernicus' proposal convincing not because it better fit the observations of planetary positions but because of its simplicity and elegance, in contrast to the complicated epicycles of the Ptolemaic model. (Hawking, 2002, p.ix)

The beauty of mathematics lies in this "perfection", in this "everything fits", in this "everything makes sense"; as in a work of art: everything in balance, the parts, the relationship between the various elements, the various events, the design, the harmony, the texture. Beauty and truth. Paul Valéry (1995, p. 49) had reflected on this subject matter as well:

> Mathematicians never stop talking about the beauty of the structure of their arguments and their demonstrations. Their discoveries are made by means of the perception of analogy of forms.[3]

Graham Farmelo (2003b) classifies the equations of modern science in the aptly titled book *It Must Be Beautiful*. Beautiful seems to be a condition *sine qua non* for true. Buckminster Fuller (1895-1983) (cited in Livio, 2003: 10) once put it:

> When I am working on a problem, I never think about beauty. I think only of how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong.

And as Einstein's eldest son, Hans, explained: "not beautiful" is a mistake.

Siân Ede (2005, p. 186) describes how – based on beauty – some scientists claim for themselves the role of artists. The author explains, as an example, how they claim that the images they produce using the new scanning technologies possess a beauty that is sufficient unto itself; they consider it a new form of abstract art. Putting the discussion of whether it is art or not to one side, it is interesting to discover how beauty is once again seen both as a warranty for truth and a goal in itself, in art and science.

5. On architecture for the future

As the boundaries are not clear - between art, science, creativity, beauty – everything is open to discussion. Science – more specifically, neuroscience – seems to confirm that, after all, the brain of the artist and the scientist work in the same way. Furthermore, the epistemological structure of knowledge has been questioned, and we are now seeing several proposals for change. By way of example, one can refer to Margaret A. Boden's (1996a, p.289) considerations on creativity (already mentioned before): mainly that creativity is involved in several different kinds of thought processes and its study is

[3] [Free translation. Or: "Os matemáticos não param de falar da beleza da estrutura dos seus raciocínios e das suas demonstrações. As suas descobertas desenvolvem-se através da percepção de analogia de formas."]

"inescapably interdisciplinary." And as beauty is not restrictive to art, but is accepted or even transversally pursued, all perspectives seem to be possible.

Picon and Ponte (2003, p. 11) clarify that throughout history

> the sciences have served as a source of images and metaphors for architecture and have had a direct influence on the shaping of built space. In recent years, architects have been looking again at science as a source of inspiration in the production of their designs and constructions.

At the same time "[a]rchitecture has provided images for scientific and technological discourse also." There is an "exchange between the two domains". (Picon and Ponte, 2003, p. 11.) Establishing a different link, one interrelating architecture with music, Marcos Novak (b. 1957) is one author who, through the digital world, creates a new interdisciplinary relationship between architecture and music: "archimusic" – the fusion of both disciplines. Music serves as a basis, for, according to Novak, "music has reinvented itself in far more profound ways than architecture has dared" (Novak, 1994, p. 69) and may serve as an example to architecture.

The awareness that there is, beyond the visible world of everyday life, a macrocosmic and a microcosmic world, forces us to think about some fundamental questions: is the existence of architecture in this visible and sensitive world of everyday life a destiny? Can, or not, a parallel be drawn between the worlds of art and science, with the transposition of concepts? By this, I mean to reflect on architecture as a specific way of reasoning, a *design* (not necessarily constructed). Free of constraints. Using Margaret A. Boden's (1996a, pp. 271-272) concept of "dropping a constraint". While explaining what is understood by conceptual spaces, within other examples, she alludes to, for instance, how Arnold Schoenberg (1874-1951) created atonal music by ignoring the "home-key" constraint. What is proposed here is to drop gravity and human scale (for now...). This idea may be seen as a follow-up to earlier experiences, such as those of Claude-Nicolas Ledoux (1736-1806), whose built work lacks the sublime magic of his drawings. The same applies to Étienne-Louis Boullée's (1728-1799) drawings. Their value depends on a non-existent building technique, on an impossible existence.

The traditional edifice of architecture will become something for which we do not yet have a name.

To use Federico Mayor (2001, p. 5) term, to "surpass reality" (as quoted above) is the primary goal.

Acknowledgements

This paper was funded by National Funds through FCT – Fundação para a Ciência e a Tecnologia under the Project UID/AUR/04026/2019.

Bibliographical References

Andreasen, Nancy C. and Ramchandran, Kanchna. (2012). Creativity in art and science: are there two cultures? *Dialogues in Clinical Neuroscience*, 14(1), pp. 49-54.

Boden, Margaret A. (1996a). Creativity. In Boden, Margaret A. (Ed.). *Artificial Intelligence* (pp. 267-291). Cambridge, Mass.: Academic Press.

Boden, Margaret A. (Ed.). (1996b). *Dimensions of Creativity*. Cambridge, Mass.: MIT Press.

Bronovski, J. & Mazlisch, Bruce. (1988) *A tradição intelectual do Ocidente*. Lisboa: Edições 70.

Carchia, Gianni. (2009). Criatividade. In Carchia, Gianni & D'Angelo, Paolo (Ed.s). *Dicionário de estética* (pp. 83-85). Lisboa: Edições 70.

Ede, Siân. (2005). *Art and Science*. London: I. B. Tauris.

Farmelo, Graham. (2003a). Foreword: It Must be Beautiful. In Farmelo, Graham (Ed.). *It Must Be Beautiful: Great Equations of Modern Science* (pp. xi-xviii). London: Granta Books.

Farmelo, Graham. (Ed.). (2003b). *It Must Be Beautiful: Great Equations of Modern Science*. London: Granta Books.

Garfield, Eugene. (1989). Art and Science. Part 1. The Art-Science Connection. In Garfiel, Eugene. *Essays of an Information Scientist: Creativity, Delayed Recognition, and other Essays* (pp. 54-61). Philadelphia, Penn., ISI Press.

Hawking, Stephen. (2002). Introduction. In Kepler, Johannes. *Harmonies of the World: Book Five*. Philadelphia, Penn: Running Press.

Livio, Mario. (2003). *The Story of Phi, the World's Most Astonishing Number*. New York, N.Y.: Broadway Books.

Mayor, Federico. (2001). Preface. In Strosberg, Eliane. *Art and Science* (p. 5). New York, N.Y.: Abbeville Press

Novak, Marcos. (1994). Breaking the Cage. *Pamphlet*

Architecture. Architecture as a Translation of Music. Martin, Elizabeth. (Ed.). (16), pp. 69-71.

Ortega y Gasset, José. (1963). *Obras Completas*. Madrid: Revista de Occidente.

Pelletier, Louise, & Pérez-Gómez, Alberto. (1994). *Architecture, Ethics and Technology*. Ottawa: Carleton University Press.

Penrose, Roger. (1990). *The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics*. Oxford: Oxford University Press.

Picon, Antoine and Ponte, Alessandra (Eds). (2003). *Architecture and the Sciences*. New York, NY: Princeton Architectural Press.

Russell, Bertrand. (1959). *Mysticism and Logic and Other Essays*. London: George Allen & Unwin.

Strosberg, Eliane. (2001). *Art and Science*. New York, N.Y.: Abbeville Press.

Tatarkiewicz, Wladyslaw. (1980). *A History of Six Ideas: An Essay in Aesthetics*. Dordrecht: Springer.

Valéry, Paul. (1977). *Paul Valéry: An Anthology* (Lawler, James Ronald Ed.). London: Routledge & Kegan Paul.

Valéry, Paul. (1995) *Discurso sobre a Estética, Poesia e Pensamento Abstracto*. Lisboa: Vega.

Wittkower, Rudolf. (1998). *Architectural Principles in the Age of Humanism*. London: Academy Editions.

Worringer, Wilhelm. (1997) *Abstraction and Empathy: A Contribution to the Psychology of Style*. Chicago, Ill.: Ivan R. Dee.