2.1 Introduction

One of the most important questions that arise due to the use of fractal geometry as form generator is that of signification.

The use of statistics in generating form is open to the question: *How do statistics give meaning to the Architecture, if at all?*

The normative position will draw two analogies: Firstly, between Architecture and Mathematics; and secondly, between Architecture and Language. Thus the study will focus on three manifestations of language, namely:

- Spoken and written language;
- Architecture as language; and
- Mathematics as language.

Both spoken and written language will be referred to collectively as language, as one of the means by which ideas and concepts are communicated between humans (Preziosi, 1979:1). Architecture has the ability to allude to cultural and historical ideas through the use of symbols and can therefore be considered a language (Curl, 1999:653). Similarly, mathematics can be used to organise cognitive activities, clarify concepts and to represent certain entities and can therefore, also be considered as a language (Agostini, 1983:29).

2.2 Language

Language is defined as…

> *"…a system of communication which consists of a set of sounds and written symbols which are used by the people of a particular country for talking or writing…"* (Sinclair, 1988:439).

It is also referred to as other means of communication such as sign language, computer language and animal language. It is therefore necessary to look at Semiotics in Architecture as it aims to answer the question of *meaning* in Architecture. The question of meaning in Architecture is one that has been under intense scrutiny, especially since the 1960s when there was an in-depth interest in Architecture as a visual language and the challenges of applying the "linguistic analogy" to Architecture (Nesbitt, 1995: 110).

It is important to note that there is a clear distinction between the study of Communication theory and Semiotics. Semiotics specifically denotes the study of signification, thus the production of meaning in the relationship between the signifier and the signified.

The three different 'languages' namely, Architecture, Normal Language (as defined earlier) and Mathematics, are automatically divided into three different levels of ambiguity, while displaying enough similarity to make such an analogy viable. These levels of ambiguity are explained in Table 2-1.

Table 2-1: Levels of ambiguity within Architecture, Normal Language and Mathematics as languages

	Social contract[1]	**Ambiguity and interpretation**	**Well defined signs**
Architecture	No	Completely open and ambiguous	No
Normal language	Reasonably clear	Reasonably clear	Reasonably clear
Mathematics	Yes	No ambiguity	Yes

[1] 'Social Contract' refers to two individuals concurring on the meaning of a sign to make communication possible, for example, when referring to a 'cat' there is a set of possible meanings that can be attached to it based on the social contract between two people (Nesbitt, 1995:133).

As summarised in Table 2-1, Architecture has the ability to be very ambiguous, to the point where interpreting the sign is completely open-ended and even borders on total non-interpretation.

Normal language, on the other hand, can bridge the open-ended to the specific interpretation due to its descriptive nature, but is still ambiguous in the sense that the receiver filters language into his own understanding of words and their meaning. Lastly, mathematics is completely devoid of ambiguity and interpretation. The symbols and conventions are above the issues of mother tongue and place of origin.

It is important to realise that there are certain limitations to the two analogies between Architecture and language and secondly, between Architecture and mathematics.

2.3 Architecture and language

This section focuses on the work of mostly Umberto Eco and his thoughts on Semiotics as a starting point for the theoretical position. This is relevant to a study of this nature in that it explores the existence of Architecture as a language, the study of language itself and the similarities between the two.

2.3.1 Why does it exist? Aspects of function and literature

In his publication *On Literature* (2002), Umberto Eco states that literature is consumed for its own sake and therefore has no clear purpose. However, Eco points out that a reductionist view like this diminishes the value of literature (Eco, 2002:2). This immediately creates a differentiation between literature and Architecture that rarely is without purpose. More than a century ago John Ruskin defined a building's function as inseparable to the point that is a duty:

> *"We require from buildings, as from men, two kinds of goodness: first, the doing of their practical duty well; then that they be graceful and pleasing in doing it; which in itself is another form of duty…"* (Ruskin, 1907).

This functionalist approach to Architecture is what Geoffrey Broadbent warns against in his 1977 article on the exploration of the possibility of meaning in Architecture through linguistic analogy (Nesbitt, 1995: 124).

A concept that pervades the study of literature and prose is the fact that literature is often compared to a musical score. The author believes that the analogy between literature and music is valid, but exploring it in this study would increase the scope to unmanageable proportions.

2.3.2 Symbolism, literature and architecture

Is architecture comparable to literature and poetics and their underlying symbolism? This question is answered by Preziosi (1979:9) when he states that…

> *"The built environment is no more an 'art', than is verbal language-except insofar as a given formation may reveal a dominance of focus upon its own signalization, precisely paralleling the 'poetic function of a linguistic art."*

In fact, Goethe states that true symbolism is when the particular represents the general *and "…*not as a dream or shadow, but as a living, instantaneous revelation of the inscrutable…" (Goethe, 1918: 314).

As discussed earlier, language has the ability to be ambiguous and it is therefore not surprising that Eco refers to a symbol in literature having the ability to be either very clear or very obscure and ambiguous (Eco, 2002: 141).

Eco further feels that there is something yet beyond the symbol that he refers to as the symbolic mode (Eco, 2002:152). He bases his definition on the writings of St. Augustine, who stated that certain biblical texts have a phrase that has a certain meaning, but could just as easily been omitted. This immediately makes the human mind question the apparent meaning and removes it from metaphorical or allegorical writing that is apparent in Post-modern Architecture.

In a similar way, certain references within the Post-modern in Architecture create questions in the observer's mind based on its triviality. The uncompleted columns of Ricardo's Bofill's *Pyramid Le Perthus* (1976) in Catalonia, as seen in Figure 2-1, serve as a prime example of this.

The building triggers the reader into questioning whether there is an alternative meaning. It is as if the almost blasé placement in the work makes one wonder if there is not some double meaning programmed into it.

It is this innocent incongruity with the work that triggers us to look for meaning (Eco, 2002:153). This pens up the door to multiple interpretations. Thereby, elements can be used to trigger double meaning as is.

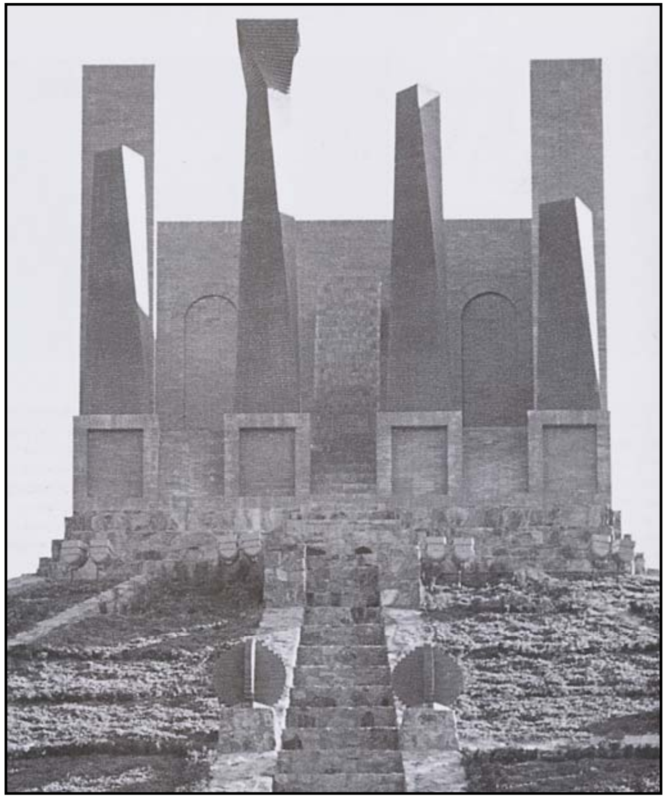

Figure 2-1: Ricardo Bofill's Pyramid Le Perthus, 1976, Catalonia *(Source: Norberg-Schulz, 2000:112)*

This incongruity in a work, literature or otherwise is not due to a lack of logic or due to frivolity. Eco states that sometimes the symbolic mode exhibits a rigid, almost paranoid logic of its own.

> *"In a more limited sense postmodern describes a design orientation that depends upon the creative manipulation of symbols and explicit references drawn from history or popular culture…"* (Doordan, 2001: 207).

In the context of this study, the conclusion is made that the symbol can be constructed from a system in its own right, which in this case, will be the symbolism of mathematical analogy and the contemporary condition. It is clear from Eco's writing that the symbolic can take center stage and represent something without boldly stipulating the obvious meaning.

This study will utilise the symbolic mode throughout, from concept to design manifestation. It will be done without forcing the user to 'understand' the symbolism. The author will rejoice even in contradictory interpretations of the symbol. The user's subjective interpretation is set both within, and as a snapshot of, the contemporary condition; and as such, is in a state of constant dynamic flux.

In an interesting way the words of Robert Venturi come to mind when he states in the opening paragraph of *Complexity and Contradiction*:

> *"Architects can no longer afford to be intimidated by the puritanically moral language of Modern architecture. I like elements that are hybrid rather than 'pure'… I am for richness of meaning rather than clarity of meaning: for the implicit function as well as the explicit function…"* (Venturi, 1966, 22-3).

Although this idea seems completely absurd in today's world, it made sense in his historical setting. He thus proposed that an argument could be solved by calculating the answer based on the logical steps in thought that it involved (Agostini, 1983:29-30).

2.4 Architecture and Mathematics

Mathematics can be defined as…

> *"The science of magnitude and number, and of all their relations…"* (Poole, 1954: 655) and *"The study of numbers, quantities or shapes."* (Sinclair, 1988: 482).

One of the beauties of mathematics is its characteristics of economy and simplicity. With the symbols of 0-9 and a decimal point, any number, no matter how big or small, can be denoted by changing the position of the symbol. There is no other symbolic system so simple or so effective (Agostini, 1983).

> *"One of the strangest relationships between mathematics and the 'real world and also its strongest, is that good mathematics, whatever its source, eventually turns out to be useful… Mathematics uses symbols, but it no more is those symbols mathematics, than music is musical notation or language is strings of letters from an alphabet…"* (Stewart, 1995:21-40).

One of the fundamental characteristics of mathematics is the fact that it is a language.

Language is there to organise cognitive activities, clarify concepts and to represent certain entities. All of the above are successfully accomplished by mathematics. It is therefore safe to say that disconnecting mathematics from the everyday language as a mental construct is artificial and absurd (Agostini, 1983:29).

Although it is true that mathematics is more apt at dealing with a certain type of problem, there is no justification for a separation in knowledge. Unlike ordinary spoken or written language, the symbols used in mathematics are unambiguous. There is thus very little, if anything, left open to interpretation in the field of Mathematical notation. It can be said that large parts of mathematical representations are completely univocal, having only one meaning or being one of voice (Agostini, 1983:30).

Gottfreid von Leibniz proposed that this meant that mathematics could be used to create a vocabulary of human thoughts that are specific enough that they could be represented symbolically. His approach is very clear when he states:

> *"All thought has universal characteristics that allow it to be reduced to abstract symbols…"* (Steele, 2001:14).

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2.5 Fractals

Fractals can be considered a subdivision of the language of mathematics and will be utilised as mediation between the reality of our world and the generation of form for the purpose of design.

A fractal is a geometrical motif that repeats itself over and over at ever smaller scale (Hersey, 2001:167). It is widely recognised that fractals are all around us, whether in the form of clouds, trees, or the shapes of mountains and coastlines.

This means that perhaps their value to us is more than mathematical coincidence. They have been used in explaining the spatiality of these phenomena and thus, eliminating the possibility of randomness and chaos in explaining the patterns' existence (Anton & Rorres, 1994:699; Stewart, 1995:3).

Upon diving into the field of mathematics and linear algebra, the definition of a fractal becomes quite different and a large amount of pre-knowledge about the field of Linear Algebra becomes necessary. It will suffice to say that it is not necessary for the author to enter upon discussion about the definition here, as it would contribute very little to the understanding of the concept.

For example, an understanding of the definition of a fractal *"…a subset of Euclidian space whose Haasdorf dimension and topological dimension are not equal…"* (Anton & Rorres, 1994: 703) seems incomprehensible if the reader has no prior experience with the concepts of Linear Algebra.

The Hungarian philosopher, Arthur Koestler, invented the word *holon* to describe something that is both a whole and an identifiable part of a larger whole. It has the same origin as *hologram* (XenoDream Software, 2008). In this sense any human settlement can be considered a holon. It is both an entity in itself and simultaneously part of a greater whole.

Central to the idea of a holon, is the fractal, which is a geometrical motif that repeats itself over and over at ever smaller scale (Hersey, 2001:167). In other words, we can think of the city as an infinite multitude of parts, or networks interwoven to the nth degree. Cities, towns and villages form a self similar pattern at decreasing scales and can thus also be seen as fractals.

2.5.1 The City as Fractal

Humans have become an urbanised species, with more than half of the world's population living in urbanised environments (UNFPA, 2007). We are not unlike the Australian Compass termite, whose termitaries…

> *"…rise like tower blocks in open countryside. In this they resemble Le Corbusier's ideas for skyscraper cities… except that the termitaries are more spaciously arranged, have lower densities of inhabitants…"* (Hersey, 2001: 75).

The question that arises at this juncture is *why* are we city dwellers, and *how* do we define ourselves as such. The following definitions have been provided as an illustration of how difficult it is to define the concept of a city, without a reference to the city itself; and with reference to the inhabitants, as opposed to the built fabric:

- City: *"A large town: an incorporated town that has had a cathedral…"* (Poole, 1954:193);
- Town: *"A farmstead or similar group of houses. A municipal or political division of a country. An urban community…"* (Poole, 1954:1165);
- Urban: *"Of or belonging to a city…"* (Poole, 1954:1217); and
- Urbane: *"Pertaining to, or influenced by a city; civilized, refined, courteous, smooth-mannered…"* (Poole, 1954: 1217).

It is clear that the even the definition is devoid of a reference to individuals. By default, the definitions above refer to built fabric as a city or a town. The reference relies on definitions of smaller cities or towns, to clarify its meaning. No direct reference is made to the fact that people dwell in cities; the closest reference is that of a community.

Less obvious examples of fractals in the literature, is that of Christopher Alexander's second pattern as described in *A Pattern Language* (1977) and illustrated in Figure 2-2.

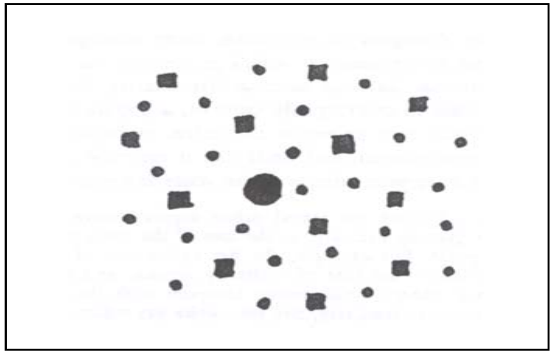

Figure 2-2: The proposed distribution of towns in A Pattern Language *(Source: Alexander, 1977:20)*

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Alexander proposes that communities should be spread out in a pattern where large towns are 250 miles apart, smaller towns of 80 miles apart and so forth, until villages are only 8 miles apart.

Another example of a fractal is that of the *Sierpinski Carpet*, as described by the Polish mathematician Waclaw Sierpinski in 1916. Figure 2-3 illustrates a pattern of bounded space in two dimensions, repeated at a smaller scale with the geometry remaining constant. It illustrates a union of eight non-overlapping repetitions of the first pattern each scaled by a third. The transformation repeats and can be extended into infinity.

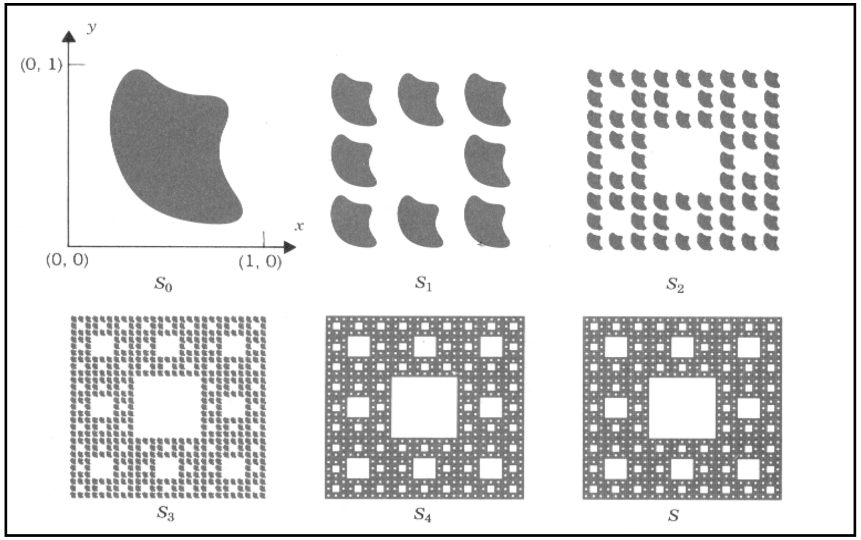

Figure 2-3: Sierpinski Carpet pattern as defined by Waclaw Sierpinski *(Source: Anton & Rorres, 1994:709)*

The similarities between Christoper Alexander's pattern (Figure 2-2) and one of the most basic examples of fractals in Linear Algebra, namely the Sierpinski Carpet.

Based on the theoretical discussion, the author is of the opinion that by utilising fractals and the existing built fabric of the city as a manifestation of human habitation, a design proposal can be created that not only flows from the site and the city, but from the patterns and habitual spatial manifestations of the very species that will inhabit it.

Doordan (2001:289) provides the following guidance:

> *"Architects have tried to provide architectural images and spatial metaphors that help people comprehend the world around them, inhabit it with some dignity, and find pleasure and stimulation in the buildings they create. This is a noble and ambitious design agenda for the architectural profession…"*

In the publication *Architecture, Language and Meaning* (1979:15), Preziosi asks the question …

"In what ways do built forms mark the presence of human individuals and groups, and how do made environments serve as data banks for socio-cultural information."

Human settlement patterns and the varied ordering thereof therefore serve as a databank of information that can be utilised to explore new forms.

Socio-cultural information is usually portrayed as statistics that deal with quantified entities, for example, population sizes and literacy levels. Certain of these sets of information are generally defined at a specific time for a specific set of circumstances. It can thus be assumed that they represent some form of abstracted 'snapshot' of a given situation, time and place.

2.5.2 Where to now? Application

Even though the three concepts, namely Architecture, normal language and mathematics were treated as three different entities up to this point, it is important to understand that this study will be taking a stance that these concepts are inseparable on a theoretical, philosophical and physical level. The concept of Fractals and how they will be applied and what other applications they can be utilised in will be discussed in more detail in Chapter 6 under Methodology. It is however important to define the theoretical stance of the application at this point.

Generating architectural form, designing *genetic material* the computer can process data to create new architectural morphologies. Computational Architecture pursues various methods through which the role of the designer can shift from *space programming* to *programming space*; through the designation of software programs to generate space and form from the rule-based logic inherent in architectural programs, typologies and building codes.

Computational architecture explores the viability of mathematical computation as a method of design. It is important to note that even in this type of design process the design is not necessarily about the sudden appearance of a form, but about a combination of thoughts and processes that lead to the inception of a form. It involves the articulation of thoughts and the exploration of possibilities in the existential emergence of form.

Algorithms can be seen as a symbolic language of which the vocabulary, grammar and meaning depends on the computational power and input of the design tool.

Through this type of algorithmic transformation it allows the designer to make the attributes of the input data to visually perceptible. It is acknowledged that the limitation of this approach is that the processes themselves are arbitrary and unrelated to the site or programme. The resulting forms appear to be more a product of the translation process than of the data itself.

The author postulates that Computational architecture uses computers for their computational capability to generate forms that are an alternative to the extreme crystalline regularity of what has up to now been considered modern.

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