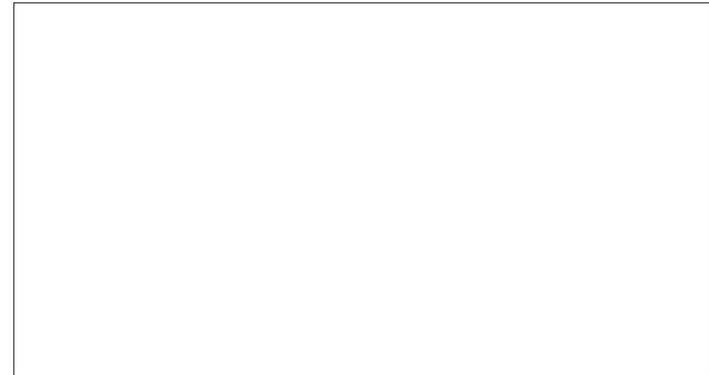
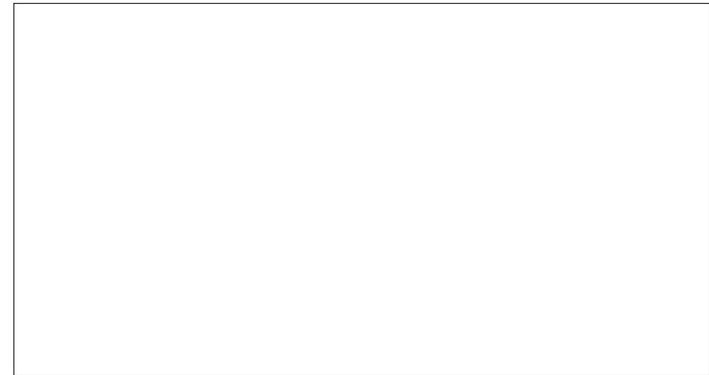
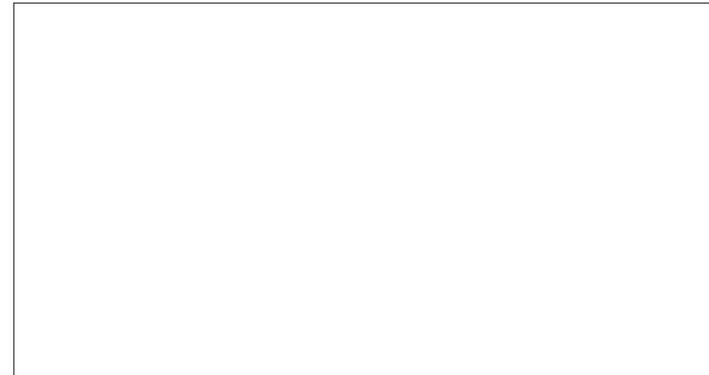
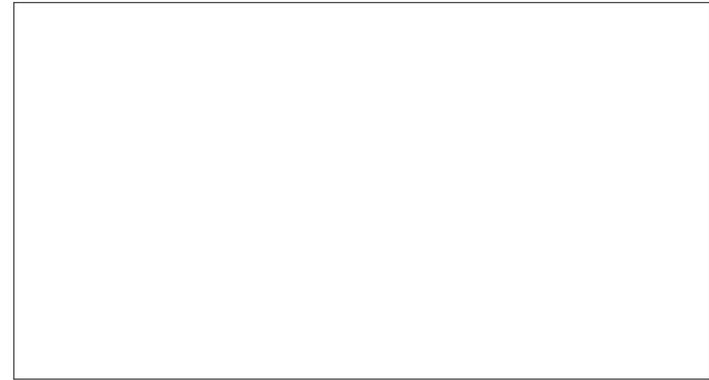


On the Limitations of Shape Grammars: Comments on Aaron Fleisher's Article "Grammatical Architecture?"

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Abstract

Shape grammars were introduced by Gips and Stiny in 1972. Since then, there have been many articles and books written by them and their associates. In 1992, Aaron Fleisher, a professor at the School of Planning, MIT, wrote a critique of their work in an article titled "Grammatical Architecture?" published in the journal *Environment and Planning B*. According to him, Gips, Stiny and later Mitchell, propose a hypothesis that states that shape grammars are presumed to represent knowledge of architectural form, that grammars are "formable," and that there is a visual correspondence to verbal grammar. The strong version of "the hypothesis requires that an architectural form be equivalent to a grammar." Fleisher considers these hypotheses unsustainable, and argues his case by analyzing the differences between language, and architecture, and by dealing with the concepts of lexicons, syntax and semantics. He concludes by stating that architectural design is negotiated in two modalities: the verbal and the visual, and that equivalences are not at issue; they do not exist. If there is such thing as a language for design, it would provide the means to maintain a discussion of the consequences in one mode, of the state and conditions of the other. Fleisher's observations serve as the basis of this paper, a tribute to him, and also an opportunity to present an outline to an alternate approach or hypothesis to shape grammars, which is "nonlinguistic" but "generative," in the sense that it uses production rules. A basic aspect of this hypothesis is that the only similarity between syntactic rules in language and some rules in architecture is that they are recursive.



On the Limitations of Shape Grammars: Comments on Aaron Fleisher's Article "Grammatical Architecture?"

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1 Introduction

Shape grammars were introduced by Gips and Stiny in 1972 (Gips and Stiny 1972). Since then, there have been many articles and books by them and their associates. In 1992, Aaron Fleisher, a professor at the School of Planning, MIT, wrote a critique of their work (Fleisher 1992). However, despite the fact that it was published over ten years ago, the community of architectural researchers remains unaware of its existence, as evidenced by the papers presented at ACADIA during the last seven conferences. This may be understandable given the fact that Fleisher's article is somewhat inaccessible by the way it is written. Nevertheless, it is very convincing by its thoroughness. It is really an abstract for a book or a series of articles. It would be very interesting if Fleisher wrote such a book considering the breadth and depth of his knowledge.

However, given that this is not the case, I have attempted to explain why Fleisher's criticism is important, why it can serve as a basis for a next step in the enterprise of representing architectural design rules as syntax production rules. This "next step" would be the subject of another article. This one focuses on what he has to say.

2 Research Methods in Architecture

Fleisher's article points out many problems with the shape grammar approach. But, these problems are not only the result of the technical limitations of the approach itself, but also of the underlying assumptions concerning research in architecture. It would be a mistake not to take these assumptions into account. Without them, it is much more difficult to understand Fleisher's criticisms as well as the field of shape grammars. Fleisher assumes that inquiry or research should follow the procedure of proposing a hypothesis, testing it, and vigorously debating its merits or shortcomings in the widest possible forum. In contrast, the shape grammar approach assumes almost the opposite by using the following precepts (Gips, Stiny, Mitchell, Knight, et. al.), which—as it turns out—are common in many areas of architectural research:

- 1) It is important to be aligned with a "new" fashionable theory or movement, and most important, at the height of its popularity. The theories favored are those in linguistics, philosophy, science or mathematics. The more abstract and recondite they are, the better.
- 2) The new theory is argued to be relevant to architecture.
- 3) The new theory as applied to architecture must have its own jargon which includes terms borrowed from other fields. The jargon can be used in a loose and casual manner.
- 4) The architectural version of the new theory is to redefine how architecture is viewed and/or thought about, designed and evaluated. It attempts to legitimize new approaches to design and frequently invalidates old ones.
- 5) The articles or books on this new theory rarely contain extensive bibliography of the field being borrowed from. If they do, they cite one or two major unapproachable works, such as *Being and Time* by Heidegger. The references that do appear are usually of colleagues who are also promoting the new architectural theory.
- 6) There is little mastery of the concepts or techniques borrowed from the other fields, which are grafted onto architecture by following all the apparent precepts and forms of theory making.

A possible explanation for why these precepts exist may have to do with LeCorbusier, Mies and Gropius, the founders of modern architecture. They borrowed heavily from industrial engineering, naval architecture, and aviation engineering (Banham 1960, 1969). By following all the apparent precepts and forms of theory making, contemporary architectural researchers hope that they will have the same impact on architecture as did Le Corbusier et al. did. It may also be the result of the perception that the most interesting intellectual and technical developments occur outside of architecture. However, since 1960, in academia, the trend is to only borrow from other academic areas.

3 Research Methods as a Variation of "Cargo Cult Science"

The way that shape grammar researchers follow all of the apparent precepts and forms of theory making suggests Richard Feynman's "cargo cult science," which was inspired by the cargo cult of the South Sea islands during the second world war (Hutchings 1997). The cult wanted to reproduce the arrival of transport aircraft containing supplies for the US armed forces. They arranged runways, fires along the runways, control towers, rigged a man with wooden headphones, and bamboo antennas. Even though they followed all of the apparent rituals of the US airman, no planes arrived.

He mentions the cult in his autobiography, "*Surely You're Joking Mr. Feynman!*," in relation to the lack understanding of the scientific endeavor of some physicists who think it is sufficient to "follow all the apparent precepts and forms of scientific

investigation, but they're missing something essential, because "... it doesn't work" (p. 340, Hutchings 1997). The something "essential" is a "kind of scientific integrity, a principle of scientific thought that corresponds to a kind of utter honesty—a kind of leaning over backwards. For example, if you're doing an experiment, you should report everything that you think might make it invalid—not only what you think is right about it: other cases that could possibly explain your results; and things you thought of that you've eliminated by some other experiment, and how they worked—to make sure the other fellow can tell they have been eliminated" (p. 341). *"If you make a theory, for example, and advertise it, or put it out, then you must also put down all the facts that disagree with it, as well as those that agree with it"* [my italics] (p. 341).

In borrowing from linguistics and mathematics, have proponents of the shape grammar theory leaned over backwards by listing the facts that disagree them? Have they ever acknowledged competing theories? Have they ever explained why their theory accounts for things nonarchitectural, such as, for example, that the Le Corbusier spiral grammar also describes sea shells (p. 148, Mitchell 1990)? The answer is "no."

Therefore, from this point of view, it is fair to argue that shape grammar approach is a type of cargo cult research by grafting linguistic theories onto architecture. This point is not superfluous because it is fundamental in understanding Fleisher's article. As the south sea islanders were impressed by the logistics of military air cargo—as well as having access to some of the cargo—so too are the shape grammar researchers very impressed by the Chomsky school of linguistics of the 1960s and 1970s. In the same way that south sea islanders attempted to invoke the arrival of cargo planes, so do the shape grammar researchers attempt to create a grammatical theory of architectural form, that is, by following all the apparent precepts and forms of theory making. Writers on shape grammars show little indication of a profound grasp of linguistic works. They tend only to refer to themselves. However, in his criticism of the shape grammar approach, Fleisher purposely takes seriously what it asserts. He takes for granted the "utter honesty" to which Feynman refers. This may be a rhetorical device in his article. However, he is utterly serious about attaining new knowledge about architecture and design whether it be by grammatical form rules, or anything else. For this reason, he is interested in what they have to say. Or better yet, as he says, is what they have to say interesting?

4 Claims Advertised by the Shape Grammar Field

To some readers, Fleisher's argument can be confusing. For example, during several seminars, I have become aware that some tend to misunderstand Fleisher's approach and conclude that his criticism is unfounded (Sundance Lab Seminars 1997). It has to do with his statement that the shape grammar enterprise is flawed because it is attempting to represent the visual—e.g.

architecture—with the verbal—e.g. rules of string grammars. They say that Fleisher is wrong because the shape grammar approach is not seriously proposing a visual/verbal relationship, even though it states it explicitly and implicitly. Agreeing or disagreeing with Fleisher depends on the research game one wants to play. If one adheres to the approach of cargo cult researchers, then indeed Fleisher is wrong. In this game it is acceptable to be loose and casual with terms such as "grammar," and go through the motions of constructing a production rule system that looks like a Chomsky grammar except that shapes are used instead of characters. Then by one or two carefully selected examples, it is "proved" that the grammar works by deriving layouts. The layouts that do not work are never mentioned (see examples of Le Corbusier spiral museum and Palladio buildings in Mitchell 1990, Stiny 1980, Stiny and Mitchell 1980).

On the other hand, if one does not accept the cargo cult approach, then Fleisher must be reckoned with. He first focuses on their claims or "advertisements" as Feynman would say, and then argues in a complicated but compelling manner that such claims are not entirely justifiable.

First the explicit claims:

- 1) Shape grammars promise "to provide the basis for describing, classifying, manipulating, extending, exploring, architectural form."
- 2) Expressions ("sentences") in the grammar "would describe consistent shapes, and therefore families of designs."
- 3) "Visual and verbal categories become equivalently expressive." That is, categories of shapes represented visually have some strict correspondence to a categories of shapes represented verbally.
- 4) (Architectural) "Style can be parsed, thereby parsimoniously explained, exhibited, referenced, compared."
- 5) "Architectural intent is considered merely a matter of assigning purpose to each rule of the grammar" (p. 221, Fleisher 1992).

These claims cannot escape the fact that they are a hypothesis about architectural design, "about designing, about the description, representation, and manipulation of architectural knowledge" (p. 221, Fleisher 1992). The hypothesis states that:

- 6) "Shape grammars are presumed to represent knowledge of architectural form."
- 7) That grammars are "formable," that there is a visual correspondence to verbal grammar.
- 8) The strong version of "the hypothesis requires that an architectural form be equivalent to a grammar" (p 221-222, Fleisher 1992).

5 How These Claims Hold Up According to Fleisher

Before we embark on the detailed version of Fleisher's argument as to why this hypothesis is not justifiable, let us consider his criticisms:

- 1) The shape grammar approach does not focus on the right question. It is not "about the rules of grammars. Those are just tactics." The fact that we can derive a layout of some building using a shape grammar only tells us that such a thing is possible for that particular layout. It "merely merits notice."
- 2) It avoids the real question, which is "the substance of the rule," that is, the hypothesis that is represented in a proposed rule.

An example of avoiding "the substance of the rule" can be seen in a paper presented at Acadia 2002, California State Polytechnic University, Pomona, by Liew (Liew 2002). A Palladio layout is generated from the bottom center to the top center, and by adding some squares around the periphery which are later deleted in order to attain the final layout. The fact that this layout can be generated this way is "worth noting," but in and of itself, explains little. What are the rules trying to say: that Palladio designed this way? Off hand, one would think that architectural designers would proceed differently. They would probably start by the central horizontal and vertical axis and work out. They probably would not add squares only to delete them later. Neither Liew's paper or the other shape grammar papers deal with this discrepancy. If we are stating that architectural designers use these rules deep down in their brains, then Liew is obligated to give some evidence that this is the case. Otherwise, we are left with the fact that for this particular type of layout, human designers will probably do it one way—or many ways—and that an algorithm can do another way. What does this mean? What do we know now that we did not know before?

3) Just because we can propose a hypothesis does not mean we should commit to it, or "hug it" as Fleisher says. We can hypothesize that aliens will take over the world through viral infections, but without hard evidence, it will not be considered interesting. And there are those hypotheses worth hugging, such as the geometry of circles representing round things. For shape grammars, "a case for hugging has yet to be made."

4) The question, "how can we represent architectural knowledge grammatically?" may not be a very interesting. "A CAD program would do as well, enlighten as much, provide freer dalliance and closer control" (p. 221, Fleisher 1992).

6 Fleisher's Argument

Fleisher's discussion goes through iterations of analyzing language, and architecture, by dealing with the concepts of lexicons, syntax and semantics.

6.1 Round 1:

Linguists and Language

What do linguists do? They develop a linguistic theory by means of a grammar that assigns a structure to sentences that are correct. They do not generate sentences. A correct sentence does not matter per se. All of us speak correctly. However, it is the grammar that is on trial by how it parses a correct sentence, and by how it helps us understand language.

The Shape Grammar Approach and the Languages of Shapes

What is an important objective of the shape grammar approach? It is the generation of structures or shapes. The grammar is judged by whether or not a shape fails visual sensibility. The shape is not assumed to be correct. The grammar is judged for the wrong reason. In contrast to language, shape grammar generation and parsing do not stand together.

6.2 Round 2:

Vocabularies in Language

A language grammar is a set of re-write or production rules on a differentiated vocabulary. The structure of sentences is given by its syntax. The words constitute a dictionary (lexicon).

Vocabulary in Architecture

Architectural "vocabulary" is not differentiated as in a language. "I am (not) sure that the vocabulary of architecture is equivalently differentiated" (p. 223, Fleisher 1992). There is an added complication though: architectural graphics (drawings) can be richly ambiguous, in contrast to a dictionary of words.

For example, a shape of a circle in an architectural drawing can be part of a sign indicating "north," a round stool in plan, a manhole cover, a lighting fixture, a decorative pattern as used Frank Lloyd Wright, and so on.

Vocabularies in Shape Grammars.

Mere shapes are not differentiated enough for a vocabulary.

6.3 Round 3:

Syntax in Language

The rules contain terminals and nonterminals. Terminals include words in a vocabulary. Nonterminals represent the phrase structure of a sentence. Production rules only operate on nonterminals. The process of applying rules, whether in parsing or generation, is finished when no nonterminals remain.

Syntax in Architecture

Just as there is no equivalently differentiated vocabulary in architecture, Fleisher also states that "I am not sure that the differentiations are equivalently syntactical" (p 223, Fleisher

1992). This means that even though there are syntactical rules in architecture, they are not the same as syntactic rules in language.

According to the *Oxford English Dictionary*, the **first** definition of “Syntax” means “1.a. Orderly or systematic arrangement of parts or elements; constitution (of body); a connected order or system of things.” The **second** definition has to do with grammar: “2. Gram., etc. A. The arrangement of words (in their appropriate forms) by which their connexion and relation in a sentence are shown” (p. 487, *Oxford English Dictionary* 1989).

I think that Fleisher is using the first definition of “syntax” in his phrase “equivalently syntactical.” By this, he means that the “Orderly or systematic arrangement of parts or elements” are not equivalent in language and in architecture. That is, for every way that elements are ordered in language, there is not an equivalent ordering in architecture.

At the same time, he is stating that shape grammars are described in terms the second definition of “syntax.” As we shall see in the next section, he has a case because shape grammars are defined as string grammars in disguise.

Syntax in Architecture According to the Shape Grammar Approach

While linguists distinguish between terminals and nonterminals and maintain such distinction in dealing with their grammars, shape grammars are defined by making the distinction and then ignoring it. “Their rules much more usually match on markers (on figures) than figures or structures. Generation proceeds by subdivision or agglutination. Markers are the only control devices explicitly described.” “Shapes have no formal finish or internal structure syntactically derived” (p. 223, Fleisher 1992).

Fleisher’s comments imply that the definition and application of shape grammars are consistent. But this is not the case. Although, his analysis shows that their methods are flawed, they are actually worse than he describes. In reviewing the articles on shape grammars, I concluded the following (Gerzso 2000):

Comparing shape grammars with standard context-free grammars is not straightforward because the definitions of shape grammars are not always consistent. According to Gips, a shape grammar is defined using string grammar terminology. He replaces words with shapes. He defines terminals as shapes, nonterminals as markers that are associated with shapes, and production rules as rewriting rules of shapes (p. 5 and p. 10, Gips 1974). Most of his grammars contain only one nonterminal. He shows how shape grammars can produce embedded or inscribed squares, arrays, snowflakes, and Hilbert curves. In one of the subsequent definitions of shape grammars, the explicit specification of terminals and nonterminals is dropped (p. 347, Stiny 1980). The grammars are cast as sets of lines. In this guise, they seem to be a variation of graphs. An interesting conjecture is that shape grammars

are a subclass of graph grammars (Rozenberg 1997). In his explanation of his definitions, Stiny seems to be saying that terminals are shapes and that nonterminals are labeled shapes. A marker in the Gips sense is a type of labeled shape. Terminals and nonterminals exist albeit implicitly. In another version (p. 143, p. 147, and p. 148, Mitchell 1990), the definitions include once again the explicit notion of terminals, but nonterminals remain implicit as markers. The presentations of the definitions of shape grammars usually include only one marker or nonterminal. What does this mean? One could argue that a shape grammar with one nonterminal is like defining a string grammar in which the syntax only permits concatenating one type of word, such as nouns. This may be interesting in studying algorithms, but not in studying architecture or languages—natural or artificial. In applying shape grammars to specific architectural examples, the shape grammar formalism changes once again. Stiny presents the idea of applying shape production rules in two or more stages so as to be able to produce Mughul gardens (Stiny 1980) and Palladio villas (Mitchell 1990). For each stage, there is a set of rules to be applied. However, taken as a whole, shape grammars are no longer grammars in the CFG (context free grammars) sense. The rules in the first stage are CFG’s, but the rules of the remaining phases are related to Chomsky transformation rules: (p. 89, Smith and Wilson 1979).

The structure of the shape grammar rules bolsters Fleisher’s claim that they express a hypothesis that the rules about architectural form are equivalent to a grammar. He says “I do not know whether it was also noticed that the production is still a string: that the dimensionality of the shape resides entirely in the figures that are strung: that these productions cannot distinguish, do not understand top, bottom, back, front, within, or without of either figure or shape; . . .” (p. 222, Fleisher 1992).

In other words, shape grammars look like they are graphical representations of form, but upon close inspection, they are not. Consider the rules for a half-hexagon table, a simple grammar with scaling, and the Le Corbuier spiral museum (p. 143, p. 147, Mitchell, 1990). They are string grammars in disguise. The linearity of string grammars is camouflaged in terms of a sequence of shapes which are generated in a linear manner with one marker. There is a string version for each one of these examples. We could easily write a string generator, produce a string, then run it through a computer program which will draw the shape or design. In computer science, these strings are commonly known as graphical languages (Foley and Van Dam 1982). The interpreters for these languages are ubiquitous. They reside in laser printers, plotters, ink jet printers, and video cards, to name a few. They are cousins of picture grammars (Shaw 1970). Despite this, the field of shape grammars has rarely acknowledged or taken advantage of these techniques.

However, Fleisher is not completely correct with regard to the

Palladio grammar (p. 155, Mitchell). In this case, the rules have more than one label or marker. The generation of a layout is no longer linear as in a string, which gives rise to an additional complication. Specifically, at the the fifth step of the derivation, it is possible to apply a rule on either the right side or left side of a square with markers. This means that a Palladio layout can be generated in more than one way, that is, it is not deterministic. In string grammars, this is also possible, but it is avoided like the plague because it makes parsing unmanageable. These types of grammars are known as ambiguous grammars (Aho and Ullman 1972).

It is tempting to use the Palladio grammars as a way to rebut Fleisher's claim that shape grammars represent an attempt to make "an architectural form be equivalent to a grammar." But the cure is worse than the disease. Nondeterministic layout generation is one reason, among many other ones that will not be considered here.

6.4 Round 4: Semantics in Language

A lexicon supplies meaning to words (for example, the word "cat" refers to a four legged furry domestic animal, as well as possibly, three other meanings). Semantics supplies meanings to sentences. Semantic analyzers are applied to units of syntax. There exists a principle of compositionality. "The meaning of a sentence is composed of the meanings of these units, . . . [These] meanings do not change as the composition accumulates" (p. 224, Fleisher 1992).

Semantics in Architecture

The principle of compositionality in architecture is debatable. In contrast to reading, seeing is an act of renewable and revisable organization. "To look is to reason" (p 224, Fleisher 1992). The meaning of a shape cannot always be the accumulation of the meanings of sub-shapes.

Semantics in Architecture According to the Shape Grammar Approach

Shape grammars are purported to produce emergent forms. That is, figures can be distinguished in a serendipitous and unanticipated manner as a result of the combinations of other figures. This is a deadly mistake. It violates the principle of compositionality. The consequence is that the meaning of each shape in an aggregation of shapes will change as new shapes are added.

In order to understand this, consider the following hypothetical generation of a layout: a shape that represents a bathroom at one stage, but as a result of adding a shape that means "closet," the bathroom shape now means "basement," and with the addition of another shape that means "garage," the combined shapes "basement" and "closet" mean "heliport." This violates a lexical unit and semantical unit: "bathroom," "basement," and "closet."

6.5 Round 5: Semantics in Language

A lexicon (dictionary) is strongly fixed. Languages are redundant, but the order of words are spoken never varies. Therefore, the principle of compositionality is sufficiently reliable and frequent enough to transmit the meaning.

Semantics in Architecture

Visual lexicons are weakly fixed, if fixed at all. Graphic glossaries are common (such as Alexander's pattern language). Graphical dictionaries do not exist. Part of a picture reappears. It is frequent to have optical illusions. The order of "seeing" or scanning of a picture is never fixed.

Problems that the Shape Grammar Approach Has in Dealing with Semantics in Architecture

"Patterns of verbal semantics do not accommodate visual semantics comfortably" (p. 224, Fleisher 1992). This is an evident mismatch.

In languages, grammars lay structure on sentences in order to account for language capacity. This world is a given. During the design process, architects invent structure and meaning simultaneously. Their world is under construction. Neither words or meanings exist prior to making shapes. Words and meanings are assigned on trial—as we go along, to see if it works—locally and globally, and also discarded. No order and no units can be prescribed or anticipated. Architects like to do this.

7 "Whatever is a language for design?"

Whatever is the language for design is (or languages of designs), it is not what the field of shape grammars proposes, that is, the syntactical equivalence of natural language and architecture. If not, then what is? Or what must it take into account?

"However equivocal, designing is deliberate. Articulate drawings carry the architectural argument." ". . . [D]esigning is engaged as much in setting specifications as in searching solutions." But, "one would search, not thrash." "Searching must be constrained." "However, exhaustive examination, especially early in designing, is a doubtful tactic." "One would like a simple answer to a modest question: is there a good place to search?" "This generator is the language at issue" (p. 225 Fleisher 1992). "The language is for saying and seeing. Architecture is negotiated in two modalities. Equivalences are not at issue; they do not exist. The language would provide the means to maintain a discussion of the consequences in one mode, of the state and conditions of the other" (p. 225, Fleisher 1992).

Finally: "It may be that geometry is the only part of the architectural argument that is computable" (p. 225, Fleisher 1992).

Language	Architecture
there is an agreement as to what the units of a sentence are and what constitutes a sentence.	there is an agreement as to what the units of a building are and what constitutes a building
most of the time, there is an agreement as to what a sentence means.	in the everyday sense, a building has “meaning,” but not in the same way a sentences does.
groups of sentences have recurrent syntactic patterns described by a grammar. A group is referred to as a language.	some but not all groups of buildings have recurrent spatial patterns. Sometimes , there is an agreement that certain groups comprise an architecture or style, such as “Greek architecture”.

Table 1: Similarities between language and architecture.

Language	Architecture
sentences have no dimensions except for a linear sequence of characters or words	buildings have dimensions in three dimensional space.
sentences are not physical; they are not made of any materials.	in the everyday sense, buildings critically depend on building technology
other than their position in the sentence, the connectivity of sentence elements is not an issue.	all rooms in a building must have a direct or indirect connection to an outside access of the lot.
it is not common practice to permit the meaning of a sentence to change radically over time.	the “meaning” of a building can change radically: a factory becomes an apartment building, etc.
a sentence may be recorded, remembered, and reproduced many times. it can exist in several places at once.	a building comes into existence once and has a unique place in space and time.
sentences are “experienced” by thinking, uttering, hearing or reading them and during a short period of time (seconds, minutes). The sequence of sentence units is always the same.	buildings are experienced by moving around and through them. The sequence may vary constantly, which is considered an important aspect of architecture. Unlike sentences, the sequence can occur over long periods of time (hours, days, years).
to understand a sentence, it must be “experienced” in its entirety.	buildings may be experienced partially.

Table 2: Differences between language and architecture.

	Language	Architecture
	languages have recurrent patterns in their syntax.	some groups of buildings in an architecture have recurrent spatial patterns.
Math: Post production rules.	string production rules can be fashioned to account for patterns in syntax: Chomsky grammars.	diagrammatic/spatial rules can be fashioned to account for syntaxes of joined spaces, eg. spatial production rules SPR’s (Gerzso 1978, 2000).
	these grammars are recursive	SPR’s are recursive.
	Part of this hypothesis is that the <u>only</u> similarity between syntactic rules in language and <u>some</u> rules in architecture is that they are recursive. (Note: the formal mathematical definition of recursion is not being used here.)	

Table 3: The “deep” similarity between language and architecture: recursion.

An example of representing the visual—e.g. architecture—with the verbal—e.g. rules of string grammars—is the string version of an SPR of an industrialized housing system by Jorn Utzon (Gerzso 2001). For every layout of a house, there is at least one string of the SPR language. The strings can be shown to be grammatically correct. By analyzing the grammar, the strings for each layout, it becomes clear that this approach is a very limited and problematic as a design tool (Gerzso 1978).

8 Which Hypothesis to Hug? An Outline of a Proposal

Fleisher’s argument is convincing, so much so that one is tempted to abandon the production rule approach all together. But before we surrender and cut our losses, let’s start again and see what can be salvaged. We take Fleisher’s article to help to restate the question. This is the basis for making a new proposal.

The first thing is to review what similarities exist between language and architecture. Some of them have already been dealt with previously (Table 1).

The second thing to do is to identify what additional basic differences exist between language and architecture that Fleisher did not mention (Table 2).

With this, we have a specification of what production rules must take into account:

- 1) Physical objects (buildings) occupy three dimensional space.
 - 2) They are constrained by the limits of a site or lot.
 - 3) Buildings that have space occupied by material, and inhabitable space.
 - 4) The materials have been selected for their properties: structure, spatial delimitation, decoration etc. (Frampton 1995).
 - 5) The inhabitable space must be connected directly or indirectly to the access of the lot.
 - 6) The inhabitable spaces are designated for one or more uses or functions, which are usually constant over a period of years.
- In order that we may hug the production rule hypothesis, how must these rules be fashioned? A first take on parts of the hypothesis (Gerzso 1978, 2000):
- 7) Some layouts can be accounted for with production rules. Which ones are those? They are SAR housing design method (Habraken 1976), Trulli (Allen 1969), Utzon (Weston 2002), and San Francisco Victorian houses (Vernez Moudon 1986), among others.
 - 8) The form of the rules are divisionary: given a lot, architects divide space up.
 - 9) The rules contain diagrams for representing chunks of space that contain materials, or are inhabitable space. They are nonstring rules called Spatial Production Rules (SPR's).
 - 10) The form of the rules assure connectivity of each space to outside of lot. Examples: SPR's.
 - 11) The form of the rules depends on the building technology: one rule based on stone masonry will be different from the one based on steel curtain wall.

As a result, hypothesis about the similarity between language and architecture begins to take form (Table 3).

This is weird, subtle, and possibly interesting.

9 Conclusions: The New Hypothesis and Shape Grammars

The approach presented above is different from that of shape grammars, which asserts that architectural spatial syntax rules are grammars because they are recursive, or can be modeled by recursive rules that are a type of language grammar. That is, because recursive spatial rules look like grammars, they must be a type of grammar. It fails to take into account that production rules

are a way of modeling grammars in language, but they can also be refashioned or modified to model architecture, or something else, such as graphs. They are tools, such as a hammer, which is good for pounding nails. It turns out that there are nails to be pounded in linguistics and also in architecture. The fact that this is the case does not mean we are constructing identical structures of inquiry.

The shape grammar field fails to make this distinction. It could have remedied the discrepancy by taking into account Emil Post's work, the inventor of production rules (Davis 1994, Minsky 1967). He applied them to deal with issues of logic. He was not interested in accounting for syntax of words in a natural language, but he was interested in sentences in mathematical logic. As a result, more nails need pounding, but in a different structure.

It is also true that while considering how to construct such structures, there are other tools and fasteners available, such as screws, bolts, and the like. These options are analogous to the CAD programs that Fleisher refers to, which "enlighten as much, provide freer dalliance and closer control." By selecting a fastener, we must weigh the costs and the benefits. "Every process, or method, or tool carries a surcharge" (p. 221, Fleisher 1992).

Casting the shape grammar work as cargo cult research may strike some readers as extreme, unfair, and even biased. After all, the articles accepted for publications in *Environment and Planning B*, *ACADIA*, and other conferences, as well as the books, would seem to attest to their value. However, it is precisely these publications that are the basis of the criticism in this paper, as well as Fleisher's. Except for Mitchell (Mitchell 1990), articles on shape grammars tend to only refer to other articles in their own field, and fail to convincingly relate their work to the vast literature on grammars and graph theory in linguistics, computer science and mathematics, or even architectural history. Hersey and Freedman write, "It is curious that the two groups, those who study proportions (in architectural history) and those who study shape grammars, seem so little aware of each other's work" (p. 3 Hersey and Freedman 1992). Not only that, a small proportion of their publications are dedicated to reporting the testing of their hypothesis in terms of computer programs or design studio sessions (Chase 1999, Liew 2002). As far as I know, there are no widely used shape grammar generators downloadable from the Web.

Nevertheless: "We are indebted to the shape grammarians for pressing the argument that form can also be verbally explored. It is fundamental to the computability of architectural design." "It is awfully ingenious of the person who noticed that productions generating strings could be turned to generating shapes merely by substituting figures for the symbols in the database" (p. 222, Fleisher 1992).

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