# STYLES, GRAMMARS, AUTHORS, AND USERS

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**Abstract.** Using a grammar to understand style can be seen, for students, as involving two main tasks: cultivating a standard of stylistic correctness and converging the language defined by the grammar and the language of stylistically correct designs. I discuss a framework for organizing such an experience, consider how it informs the way we write grammars, present an example (including a grammar), and report on a classroom experience.

## 1. Introduction

Students and scholars of architecture and other visual arts often seek to understand a style based on a sample of designs in that style. What this understanding involves is explained by Stiny and Mitchell (1978b, 17, original emphasis) in the following way.

> When several buildings each create a similar impression, they are said to exemplify a particular architectural *style*. Given a finite corpus of buildings that are perceived to be alike in some sense, the problem of style consists of characterizing the basis for this likeness. Ideally this characterization has three main purposes: (1) it should clarify the underlying commonality of structure and appearance manifest for the buildings in the corpus; (2) it should supply the conventions and criteria necessary to determine whether any other building not in the original corpus is an instance of the style; and (3) it should provide the compositional machinery needed to design new buildings that are instances of the style.

These three functions can be performed by a suitable generative description of the language of designs in that style. One mechanism for articulating such a description is a shape grammar, and indeed shape grammars have been used to understand a variety of styles, from Chinese lattices (Stiny 1977) and Japanese tea houses (Knight 1981) to Wren's churches (Buelinckx 1993) and Wright's prairie houses (Koning and Eizenberg 1981).

In these and similar cases, the grammar is a hypothesis: it is based on finite empirical evidence (the corpus), accounts for that evidence (requirement 1 above), and makes predictions (requirements 2 and 3) that can be tested. And it is subject to revision, according to the correctness of its predictions.

A scholar of style tests these predictions against some standard of *stylistic correctness*. In this respect, she is like a scientist, who performs experiments which manipulate nature into evaluating her predictions, or a linguist, who asks native speakers to evaluate sentences produced by his grammar.

There is an important difference, however: stylistic correctness is almost never objective. One exception is Duarte's (2001) study of the style of a living architect. That a "native stylist" – in this case Alvaro Siza – evaluates the designs makes this study uniquely compelling.

More usually, though, no such external authority exists, and it is the author who determines stylistic correctness. She does this based on her knowledge and experience, and writes the grammar accordingly. The user studies and uses the grammar, and understands more about the style (Knight 1999–2000, "Authoring shape grammars").

But this is the style as understood by *the author*. The user does not necessarily learn how the author arrived at that understanding. Where does stylistic correctness come from? Who decides, and following what criteria? I believe that these questions are important, especially to students, who sometimes think that there is a single unambiguously correct version of a style and that their task is to learn what it is.

They should know instead that stylistic correctness can vary from person to person. As Stiny and Mitchell (1978a, 192) point out, different people "may wear different glasses." In fact, stylistic correctness can vary in the same person. It may change or develop, especially as that person sees more designs or gains more knowledge and experience.

Indeed, the most compelling aspect of stylistic correctness may be precisely that it is derived not just by observing the immediate corpus, but also by appealing to any knowledge and experience that the observer finds relevant. It matters not whether it is history, structures, function, or even a gut feeling; it is for the observer to interpret.

Thus in the end stylistic correctness is subjective. And, since stylistic correctness determines their performance, style grammars are also subjective. For any given corpus, there are as many "correct" grammars – grammars that satisfy Stiny and Mitchell's three requirements – as there are interpretations of stylistic correctness, and as many or more as there are observers.

That stylistic correctness is subjective is not obvious when connoisseurship is commonly offered as an authority; given that grammars are objective, it is even paradoxical. But to juxtapose these two tasks – composing a grammar and determining stylistic correctness – is to highlight both the limits of objective formalization and the inevitability of subjective interpretation.

We can teach students that to understand style is to interpret and apply their own knowledge and experience, and we can do it with shape grammars. In this paper, I describe a framework for just this purpose.

Briefly put, the teacher examines the corpus and formulates a working grammar, which students use to generate designs. Each student evaluates the designs, revises the grammar accordingly, and repeats until the grammar generates all and only those designs which he judges stylistically correct. In the process of evaluating the designs, the student draws on several sources of information: the corpus, the teacher's assumptions (as embodied in the grammar), and, most important, his (the student's) own knowledge and experience (for example, of history, structures, or architectural function).

Thus students have two tasks: to develop a standard of stylistic correctness, and to converge the language defined by the grammar *(the working language)* and the language of stylistically correct designs *(the target language)*. Plotting such a scenario means considering how the users – their backgrounds and agendas – affect the grammar. As we will see, there can be many points of influence.

## 2. Examining the corpus

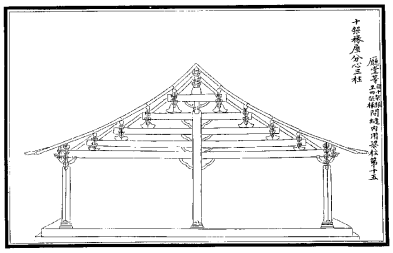
The object of study is building sections according to a twelfth-century Chinese building manual. This manual, the *Yingzao fashi,* was compiled by Li Jie (died 1110), court architect to the Huizong emperor (reigned 1101–1126) of the Song dynasty (960–1127), with the goal of setting standards and reducing corruption in official construction.[1]

In most cases, Li's instructions were not enumerative but generative. Liang Sicheng, the pioneering scholar of the *Yingzao fashi,* found this so remarkable that he called the manual "a grammar book of Chinese architecture" (Liang 1984, 358).

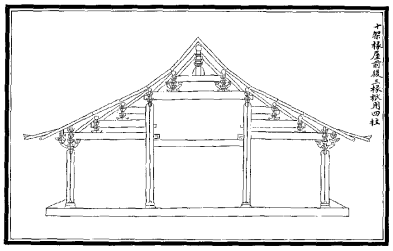
However, in some cases, Li did in fact make lists; for building sections, for example, he provided drawings and descriptions of a limited number

[1] For more in English on the *Yingzao fashi,* see Glahn (1984) and Guo (1999). In Chinese, see Liang (1983) and Chen (1993).

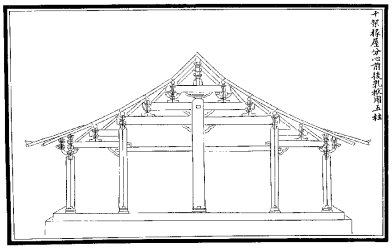
of sections.[2] In this example we are concerned with the section of only the *ting* hall, one of two main building types. Li's information on *ting* hall sections consists of a corpus: 18 drawings, each with a written description (see figure 1).



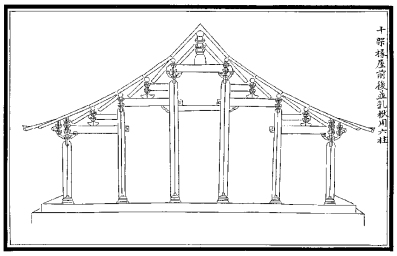
a. *Shijia chuan wu, fen xin, [yong] san zhu*. 10-rafter building, centrally divided, [with] 3 columns.



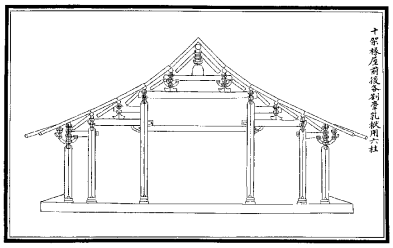
b. *Shijia chuan wu, qian hou sanchuan fu, yong si zhu*. 10-rafter building, a 3-rafter beam in front and in back, with 3 columns.



c. *Shijia chuan wu, fen xin, qian hou rufu, yong wu zhu*. 10-rafter building, centrally divided, a 2-rafter beam in front and in back, with 5 columns.



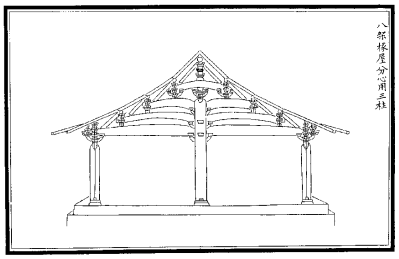
d. *Shijia chuan wu, qian hou bing rufu, yong wu zhu*. 10-rafter building, 2 2-rafter beams in front and in back, with 5 columns.



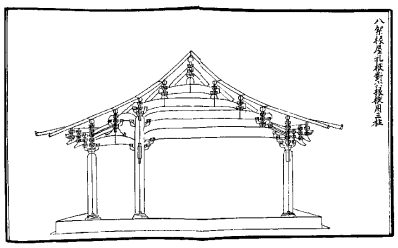
e. *Shijia chuan wu, qian hou ge zhaqian rufu, yong liu zhu*. 10-rafter building, 1- and 2-rafter beams both in front and in back, with 6 columns.

*Figure 1.* The 18 *ting* hall sections with descriptions (10-rafter buildings) (Liang 1983, 313–321).

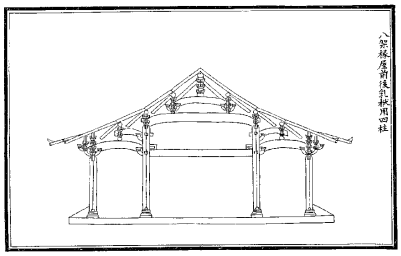
[2] The main façade of a Chinese buildings is on the long side. Thus the section of interest is the short one, perpendicular to the main façade and parallel to the approach.



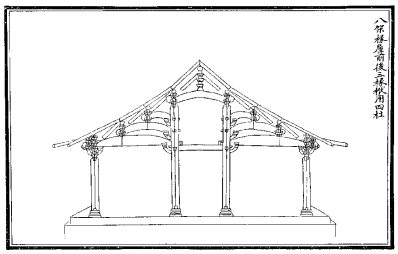
f. *Bajia chuan wu, fen xin, yong san zhu.* 8-rafter building, centrally divided, with 3 columns.



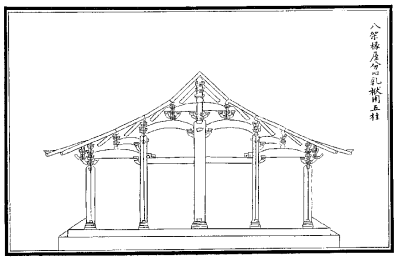
g. *Bajia chuan wu, rufu dui liuchuan fu, yong san zhu.* 8-rafter building, a 2-rafter beam abutting a 6-rafter beam, with 3 columns.



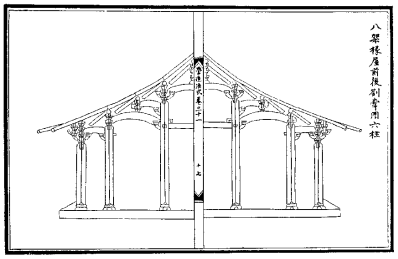
h. *Bajia chuan wu, qian hou rufu, yong si zhu.* An 8-rafter building, a 2-rafter beam in front and in back, with 4 columns.



i. *Bajia chuan wu, qian hou sanchuan fu, yong si zhu.* 8-rafter building, a 3-rafter beam in front and in back, with 4 columns.



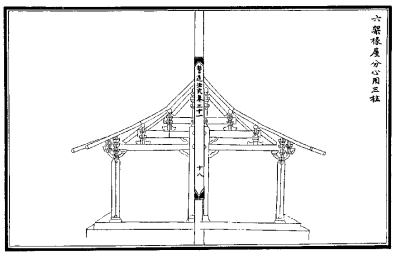
j. *Bajia chuan wu, fen xin, qian hou rufu, yong wu zhu.* 8-rafter building, centrally divided, a 2-rafter beam in front and in back, with 5 columns.



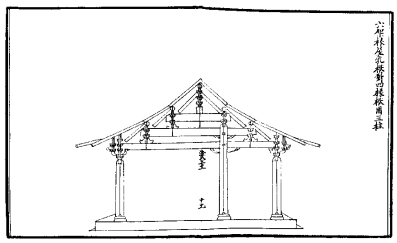
k. *Bajia chuan wu, qian hou zhaqian [rufu], yong liu zhu.* 8-rafter building, a 1- [and a 2-] rafter beam in front and in back, with 6 columns.

*Figure 1, continued.* The 18 *ting* hall sections with descriptions (8-rafter buildings) (Liang 1983, 313–321).

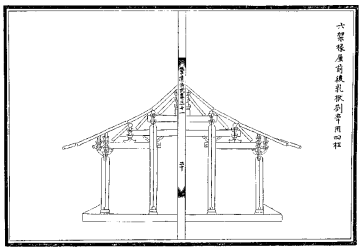
Here I make some observations on the designs in the corpus. I do this in detail, because observing is the first step in moving from individual examples to thoughts about style: from observations emerge the assumptions that are embodied in the grammar. They are my answer to the question that students should ask: *Why these rules and not others?* Different assumptions are possible, and they lead to different rules.



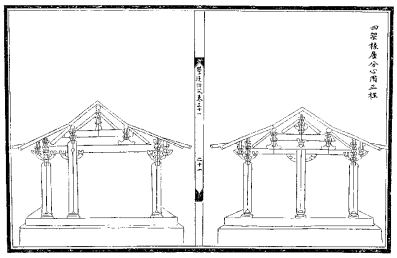
l. *Liujia chuan wu, fen xin, yong san zhu.* 6-rafter building, centrally divided, with 3 columns.



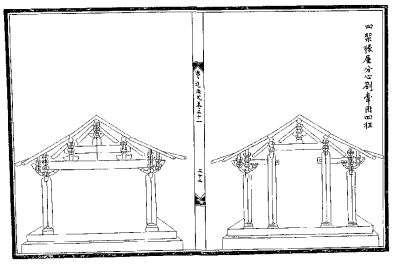
m. *Liujia chuan wu, rufu dui sichuan fu, yong san zhu.* 6-rafter building, a 4-rafter beam abutting a 2-rafter beam, with 3 columns.



n. *Liujia chuan wu, qian hou rufu, yong si zhu.* 6-rafter building, a 2-rafter beam in front and in back, with 4 columns.



o. [*Sijia chuan wu, zhaqian dui sanchuan fu, yong san zhu.* 4-rafter building, a 1-rafter beam abutting a 3-rafter beam, with 3 columns.]
p. *Sijia chuan wu, fen xin, yong san zhu.* 4-rafter building, centrally divided, with 3 columns.



q. [*Sijia chuan wu, tongyan, yong er zhu.* 4-rafter building, clear span, with 2 columns.]
r. *Sijia chuan wu, qian hou zhaqian, yong si zhu.* 4-rafter building, a 1-rafter beam in front and in back, with 4 columns.

*Figure 1, continued.* The 18 *ting* hall sections with descriptions (6- and 4-rafter buildings) (Liang 1983, 313–321).

## 2.1. STRUCTURAL ORGANIZATION

First, some principles of structural organization. Rafters *(chuan)* are not, as in the west, single components spanning from ridge to eaves. Rather, they are segmented and, in horizontal projection, equally long (except at the eaves, where they are longer). Because they are segmented, they can

form a curved roof section; this section is calculated by the procedure known as *juzhe* (Liang 1983, 265), which is the best example of Li's generative approach.

The rafters are supported by purlins *(tuan)*. Each purlin is supported at the end of a beam *(fu)*. The end of each beam is supported by a column *(zhu),* either by resting on the top of the column or by fitting into the side of the column. Each column sits either on the floor or, truncated, on a beam above the floor; the second option increases the clear floor area. The frontmost and backmost columns are always present. As we will see below, the disposition of columns is the main distinguishing characteristic of sections.

## 2.2. DESCRIPTIONS

A second observation concerns the written descriptions on the right side of the drawings. These identify components and parameters differently than we would today; they help us see what Song builders saw.

Take as an example the section in figure 1n, which has the description

> 6-rafter building, 2-rafter beams in front and back, with 4 columns
> *liujia chuan wu, qian hou rufu, yong si zhu.*

A description has three parts. The first part (*6-rafter building,* in our example) specifies the depth of the building in (horizontally projected) rafters. The corpus shows buildings with depths of 4, 6, 8, and 10 rafters.

The second part of the description *(2-rafter beams in front and back)* specifies the interior disposition of columns. Three terms are used:

1. **Clear span** *(tong yan).* The lowest beam spans from the frontmost column to the backmost column; there are no interior columns (figure 1q).
2. **Central division** *(fen xin).* There is a column below the ridge purlin (figure 1a).
3. ***n*-rafter beams** *(n-chuan fu).* There is a beam *n* rafters in length and a column supporting it (figure 1b).

A description contains these terms in the following combinations: *clear span* alone; *centrally divided* alone; *n-rafter beams* alone; *centrally divided* and *n-rafter beams.* The number of beams in front is equal to the number of beams in back. Interior beams are often unspecified.

The third part of the description *(with 4 columns)* specifies the number of columns. In an $m$-rafter building, there are $m + 1$ positions for columns. If we assume that the frontmost and backmost columns are always present, then there are $2^{(m-1)}$ dispositions of columns: 8, 32, 128, and 512 dispositions for 4-, 6-, 8-, and 10-rafter buildings, respectively.

Thus in our example the building is 6 rafters deep. There are a 2-rafter beam spanning from the frontmost column to an interior column, and a

2-rafter beam spanning from the backmost column to an interior column. There are 4 columns in total. Notice that the description specifies neither the central beam nor the space it defines, which we today would focus on. However, these features can all be inferred from the description.

### 2.3. OTHER OBSERVATIONS

Two final observations. First, for any section, only one description is given, even when another would appear to apply. For instance, the section in figure 1f does not have the description

> 8-rafter building, a 4-rafter beam abutting a 4-rafter beam, with 3 columns
> *bajia chuan wu, sichuan fu dui sichuan fu, yong san zhu.*

It would appear that a stylistically correct section can have not more than one description.

The second observation is similar to the previous one: for any description, only one section is shown. This is so even though the description does not specify all the components (such as beams, purlins, and rafters) shown in the section.

This implies that, for any description, there is only one way to complete the section. That is, the description appears to contain enough information to distinguish it from all other descriptions in the language; it appears to be *distinctive*.

Having made my observations explicitly, we are now ready to discuss the generalization of those observations: the working grammar.

## 3. Writing the working grammar

Why provide students with a working grammar? Why not have them write it themselves?

It is a matter of focus. Students do not have the time to acquire the expertise to write such a grammar from scratch. In the framework proposed here, the grammar is a means to the twin ends of learning about a style and learning how to understand a style. At the same time, students are quick to appreciate that grammars structure choices and present them graphically. These facts lead me to write the working grammar in a slightly unusual way.

The usual approach would be to take a labeled point with null descriptions as the initial design – to start from square one, as it were – and provide all the rules for generating from that a complete design, including those components not specified in the description. This suggests three main stages in the process:

1. Generate a *prepared design* consisting of a ground line, front and back columns, purlin positions, labels, and prepared description. Such a prepared design can have a depth of 4, 6, 8, or 10 rafters. (See figure 2, top node.)
2. Generate a *distinctive design,* i.e., one with just those features specified in its description. (See figure 2, second row from the bottom.)
3. Generate a *finished design:* clean up the labels, fill in the remaining structural components, and regularize the description. (See figure 2, bottom row.)

Of these three stages, only one requires the user to make any meaningful decisions: the second, creating a distinctive design. The first stage has, according to the corpus, only four possible outcomes (a prepared section of 4, 6, 8, or 10 rafters), although other outcomes (prepared sections of other sizes) can easily be imagined. And the third stage is deterministic; this assumes of course that one description maps to one complete section, but, as we have seen, this is the case in the corpus.

This leads to the unusual approach. To focus students on the decisions they make when using the grammar – the second stage – I withhold the first and third stages, and provide only the four prepared designs and the second stage schemata.

The grammar is parametric (see figure 3). I follow Stiny's (1990, 97) formulation of a design as "an element in an *n*-ary relation among drawings, other kinds of descriptions, and correlative devices as needed." Here, a design consists of a section, a Chinese description (in *pinyin* romanization, although characters work as well), and an equivalent English description. The descriptions are handled according to Stiny (1981): simply put, the shape and its descriptions are transformed simultaneously. Here, each shape schema is associated with two description functions: one Chinese, one English.

The algorithm constructs the descriptions; the section develops accordingly. Thus the schemata are named according to the descriptions; they are as follows.

1. **Clear span** schema (CS). This leaves the "initial section" unchanged and adds *tong yan / clear span* to the descriptions.
2. **Central division** schema (CD). This instantiates a column below the ridge purlin and adds *fen xin / centrally divided* to the descriptions.
3. **Front and back beam** schemata (F1, F2, …, F9; B1, B2, …, B9). Each schema instantiates an *n*-rafter-long beam and its associated column in the front or the back of the section, and adds *qian (hou) n-chuan fu / n-rafter beam in front (in back)* to the descriptions. The labels ensure that the endpoint of the beam moves with each instantiation.

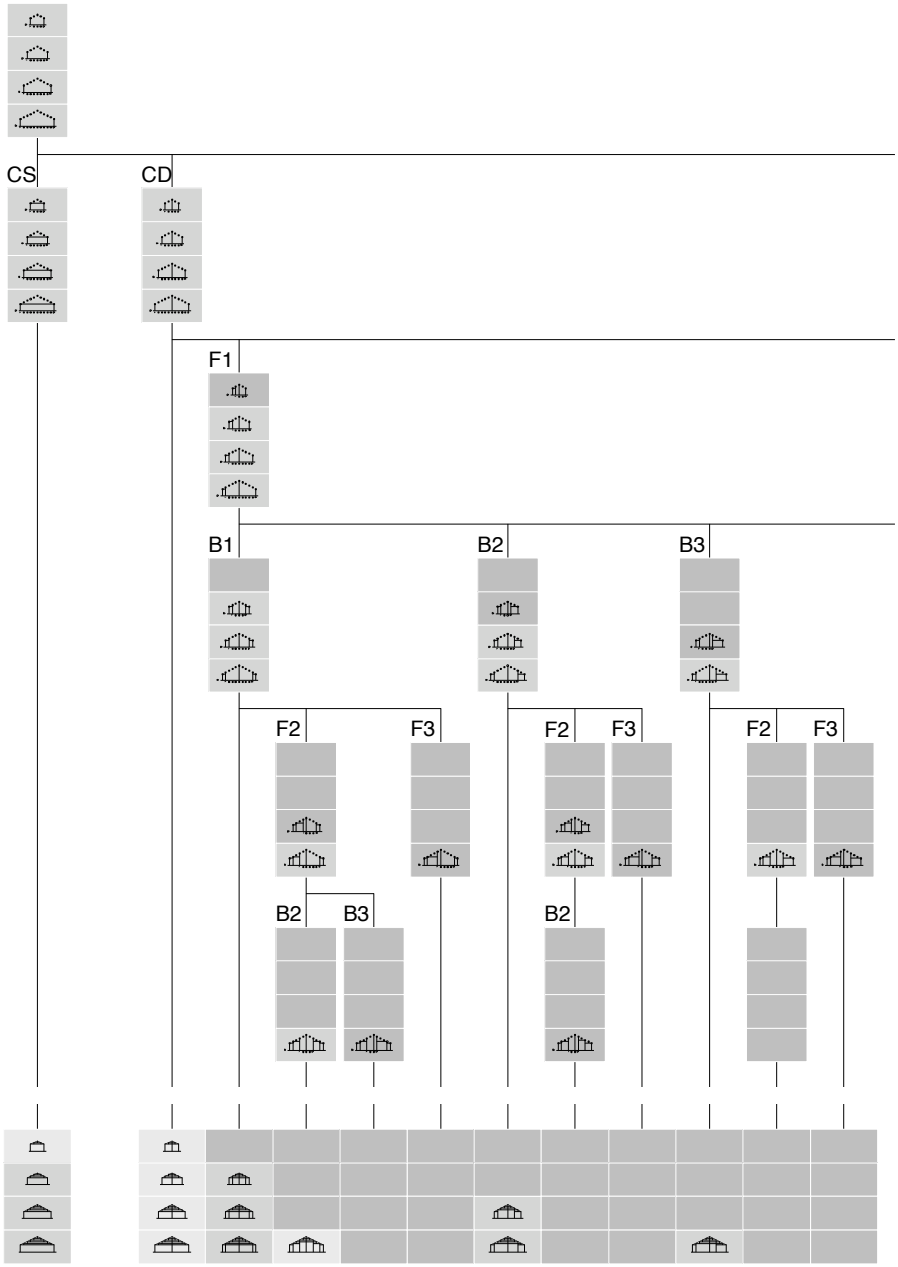



*Figure 2*. Derivation tree (leftmost 12 of 122 branches). Descriptions are omitted. Sections in the corpus have a light background. Sections that violate constraints or are found to be stylistically illegal have a dark background. All other sections have a medium background.

As I mentioned, students easily understand how shape schemata transform shapes. On the other hand, they are vexed by labels that constrain the applicability of schemata. For this reason, I use as few labels as possible, which makes the schemata more general, and express constraints verbally. This helps students understand both the transformations and the constraints better. In particular, when they revise the grammar, they often revise the constraints but not the schemata. The constraints are as follows.

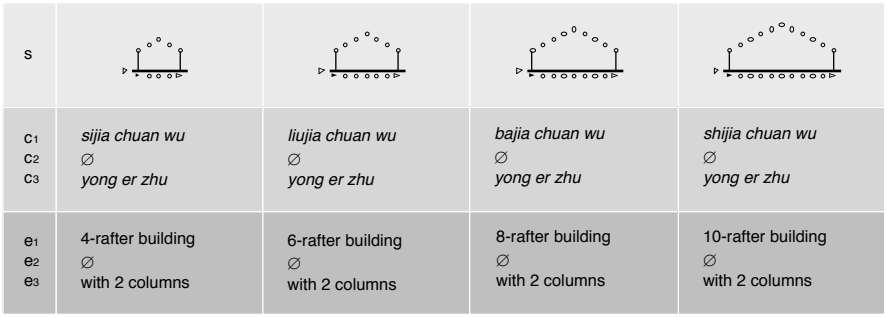



*Figure 3*. The four prepared designs (above) and the clear span and central division schemata (below).

As I mentioned, students easily understand how shape schemata transform shapes. On the other hand, they are vexed by labels that constrain the applicability of schemata. For this reason, I use as few labels as possible, which makes the schemata more general, and express constraints verbally. This helps students understand both the transformations and the constraints better. In particular, when they revise the grammar, they often revise the constraints but not the schemata. The constraints are as follows.

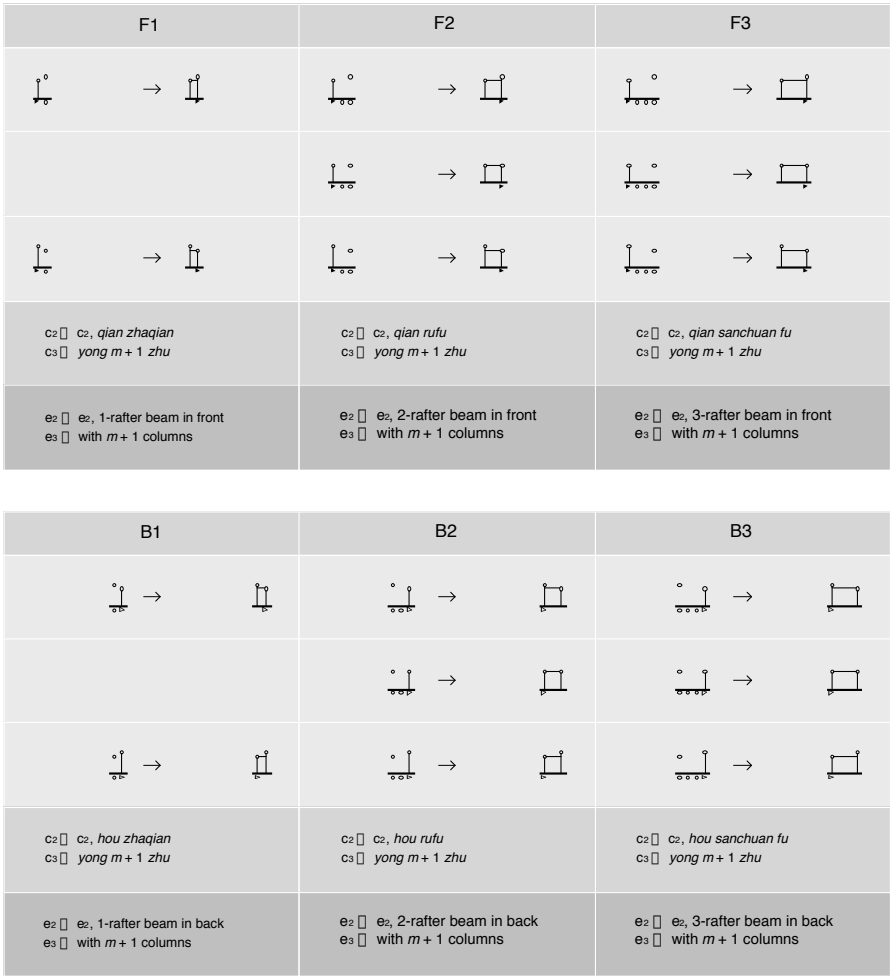



*Figure 3, continued.* The schemata for 1-, 2-, and 3-rafter beams in front (above) and in back (below).

1. Beam schemata may be applied in pairs only. That is, if a front beam schema is applied, then a back beam schema must also be applied. The lengths of the beams can be different.
2. Beam schemata may be applied as long as the new components (beam and column) do not overlap with existing components. Thus there may be more than one cycle of front-back beam instantiation.
3. A 1-rafter beam schema may be applied in the first cycle only. This means that 1-rafter beams specified in the descriptions are always in the frontmost or backmost part of the building.

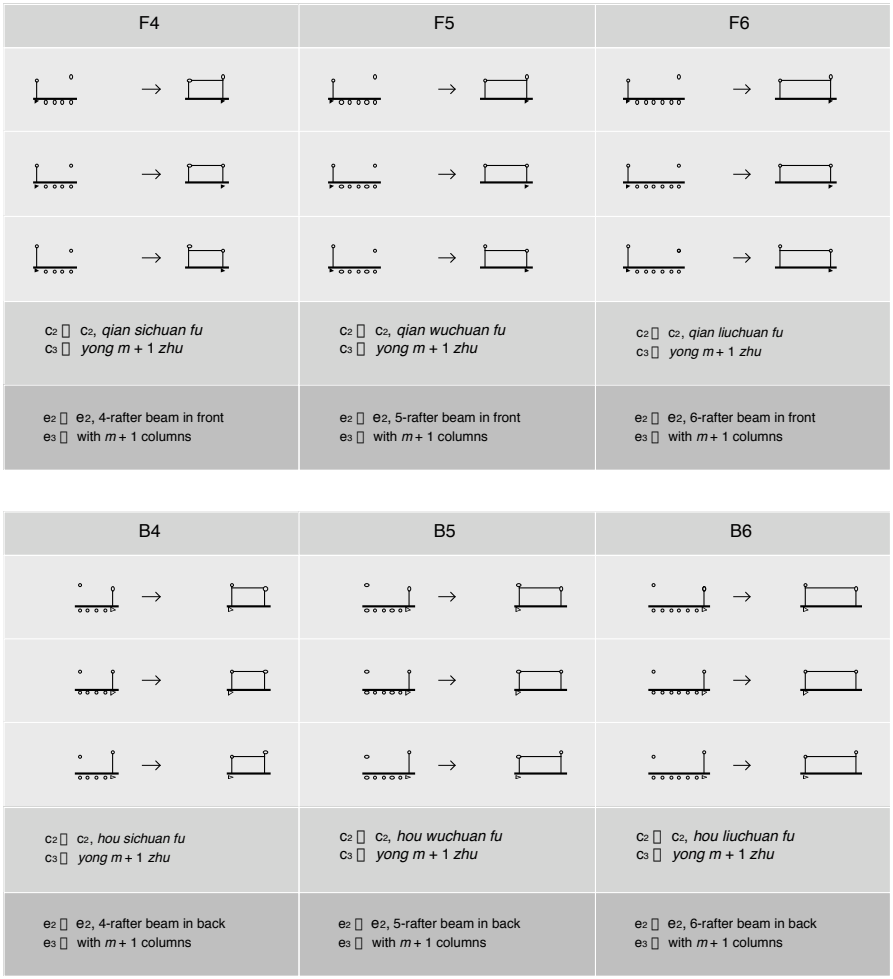



*Figure 3, continued.* The schemata for 4-, 5-, and 6-rafter beams in front (above) and in back (below).

4. The central column may be instantiated by the central division schema only, never by beam schemata. This prevents alternate descriptions, as mentioned above (figure 1f).
5. Schemata must be applied in one of the following sequences:

    a. The clear span schema only.
    b. The central division schema only.
    c. First the central division schema, and then the beam schemata (in pairs).
    d. The beam schemata only (in pairs).

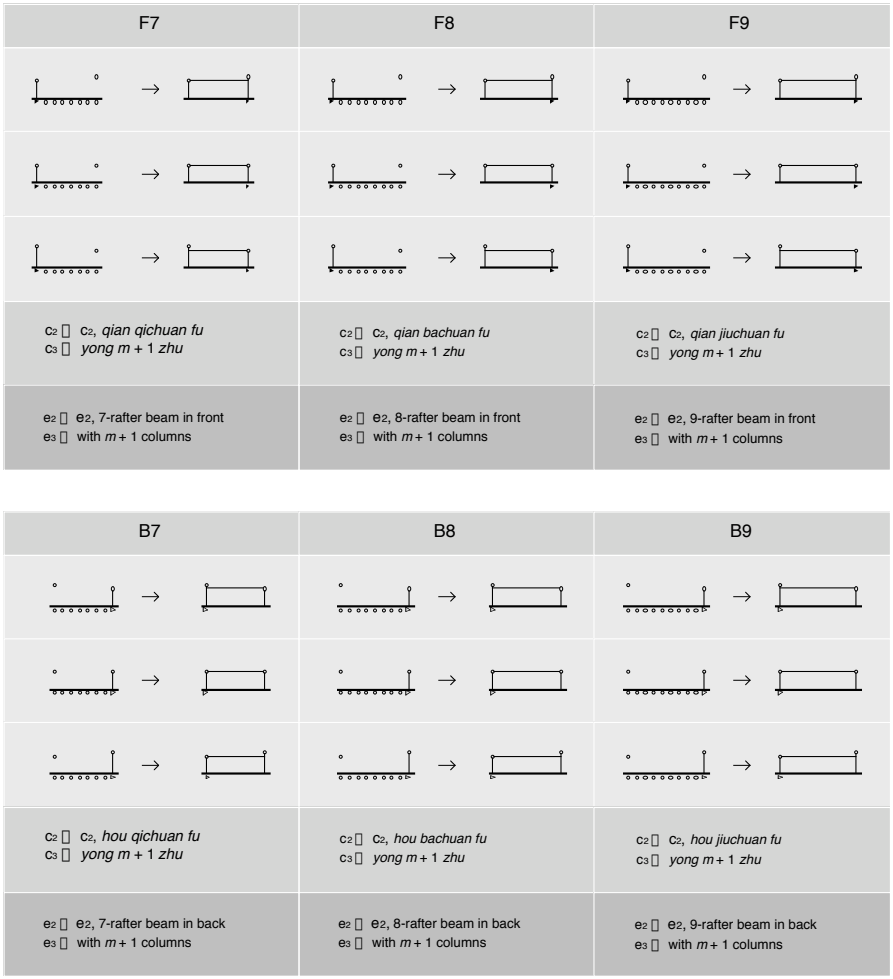



*Figure 3, continued.* The schemata for 7-, 8-, and 9-rafter beams in front (above) and in back (below).

6. Exception to constraint 2 above. A new column may overlap an existing column. In this case, the description is modified to include *dui / abutting* and the number of columns is reduced by 1 (see figure 1g). This adjustment occurs in the third stage of the grammar, and is not shown.

## 4. Understanding the working language

The working grammar defines the students' working language. To understand it, let us consider its derivation tree. This tree has 122 branches, the leftmost 12 of which can be seen in figure 2. The top of

the row consists of a single node showing the four prepared sections; the second row from the bottom shows the distinctive sections; and the bottom row shows the finished sections. All allowable schema applications are shown. The descriptions are omitted for lack of space, but they can be constructed easily.

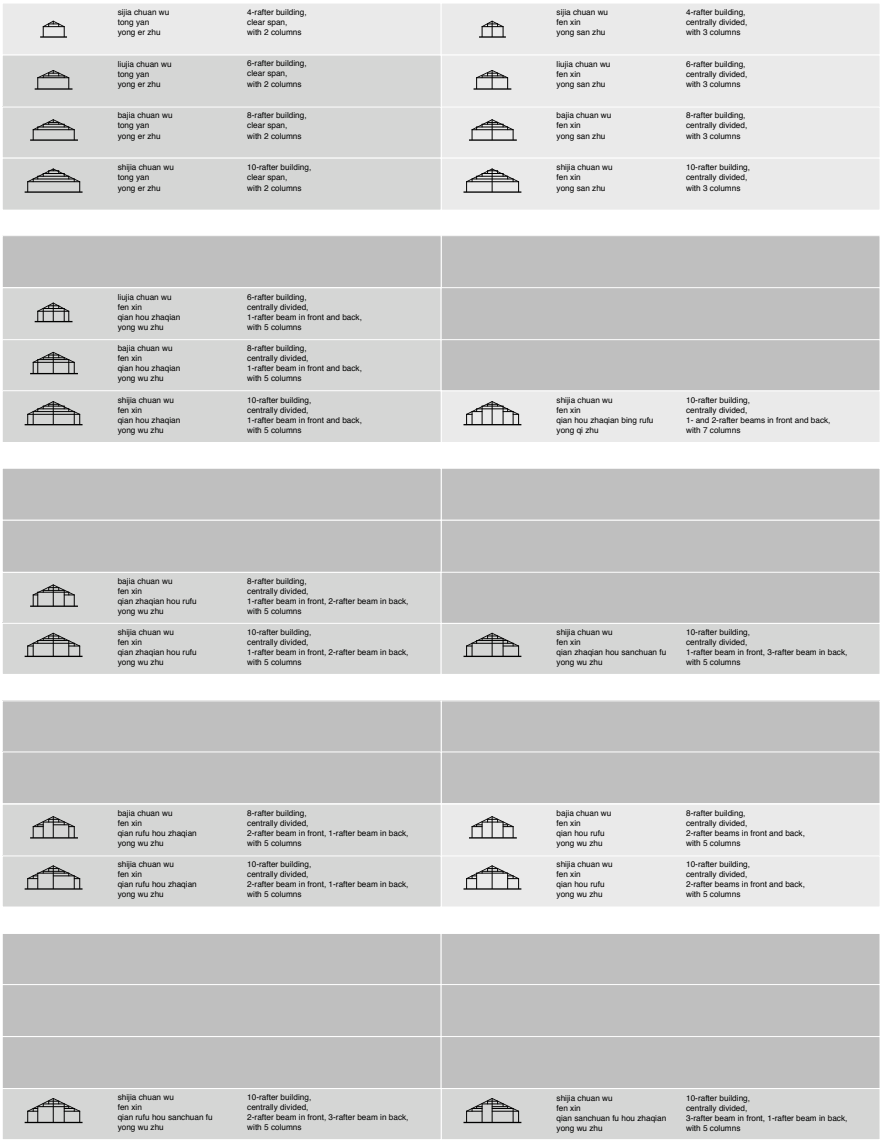



*Figure 4*. The language of designs: the 21 designs from the 10 leftmost "live" branches from the derivation tree (figure 2). The 97 designs from the remaining branches are not shown.

Each node consists of up to four sections. The prepared sections, in the top row, have medium gray backgrounds, indicating that they are not stylistically illegal. Each succeeding section in a derivation has the same color background until it is found to be stylistically illegal, usually because no schema can be applied. The derivation must stop, and no finished design results: the branch is "dead," indicated by the dark gray background. Of the 122 branches shown, 40 are dead, leaving 82 live branches containing 118 finished sections (5, 11, 30, and 72 sections of 4, 6, 8, and 10 rafters, respectively). Of these 118 finished sections, 18 (4, 3, 6, and 5 sections) belong to the corpus (indicated by light gray backgrounds). Thus the working grammar creates 100 sections to be evaluated for stylistic correctness. The first 12 of the 82 live branches are shown in figure 4.

The language can be summarized as follows:

| Depth (in rafters) | 4 | 6 | 8 | 10 | total |
|---|---|---|---|---|---|
| In corpus | 4 | 3 | 6 | 5 | 18 |
| New | 1 | 8 | 24 | 67 | 100 |
| Total | 5 | 11 | 30 | 72 | 118 |

## 5. The classroom experience

By this point, I have examined the corpus, proposed the working grammar, and sketched out the working language. The stage is set for the students to begin their task. For their part, they have prepared themselves by studying relevant excerpts and drawings from the *Yingzao fashi,* reading secondary sources, and learning the fundamentals of shape grammar and generative design. They were given the following instructions.

> Investigate the language of 6-rafter *ting* [hall] sections by reconciling a grammatical definition of that language and your understanding of stylistic correctness. … Follow these steps:
>
> 1. Using the [working] grammar, generate all the (final) designs in the language of 6-rafter sections.
> 2. You may feel that some of the designs are not in the style. Show them and explain why each is [stylistically incorrect]. Eliminate them by articulating unambiguous … constraints to eliminate them.
> 3. You may feel that there are stylistic[ally correct] designs that are not created by the grammar (these may or may not be in the corpus). If so, show them, and modify the grammar so that it creates them.
> 4. Repeat steps 1, 2, and 3 until the grammar generates all and only the stylistic[ally correct] designs.

A few remarks on the students' task. First, it is presented explicitly in terms of the framework already discussed above. Second, it is reduced to 6-rafter sections only; 4-, 8-, and 10-rafter sections have been eliminated. Third, students used a Flash-based implementation (Li 2002) to generate all the designs in the working language (step 1).

The problem appears limited, but students arrived at vastly different languages, ranging from 4 to 47 designs (see figure 5). (Contrast this with the working language of 11 designs.) They revised the constraints in different ways, invoking criteria like structure and spatial sequence. For instance:

1. A beam may be no more than 3 times as long as the abutting beam.
2. Beams in the interior of the building may not be shorter than beams on the exterior.
3. If the building has two bays, the front bay must be as deep or deeper than the back bay.
4. The building may not contain a 6-rafter beam; i.e., there is no clear span building.
5. Only a 6-rafter building may contain a 6-rafter beam. (This contradicts the corpus; see figure 1g.)

Students manipulated both rules and constraints to refine the target language. For example, the student with only 4 designs proposed 5 constraints which eliminated most designs. As for the student with 47 designs, he added 36 that do not appear in any other student's language by introducing rules to shift columns a half-rafter's length. He reasoned that such dispositions were stylistically legal after observing that some extant Chinese buildings had columns *between* the purlins, rather than directly below them.

Students understood clearly that they had to bring their own interpretation to bear on the problem of stylistic correctness. As one student wrote:

> Based on the original corpus, I get some rough idea about what designs are stylistic[ally correct]. The choice of this part is however base[d] on my own understanding and interpretation on the existing corpus that I have learned. So it depends on what and how I think about it. (Emily So Ching Han)

Another wrote:

> Everyone has different feelings, even with the same facts. … And that's the reason why every candidate's results of this exercise are different. (Dennis Leung Chung Hoo)

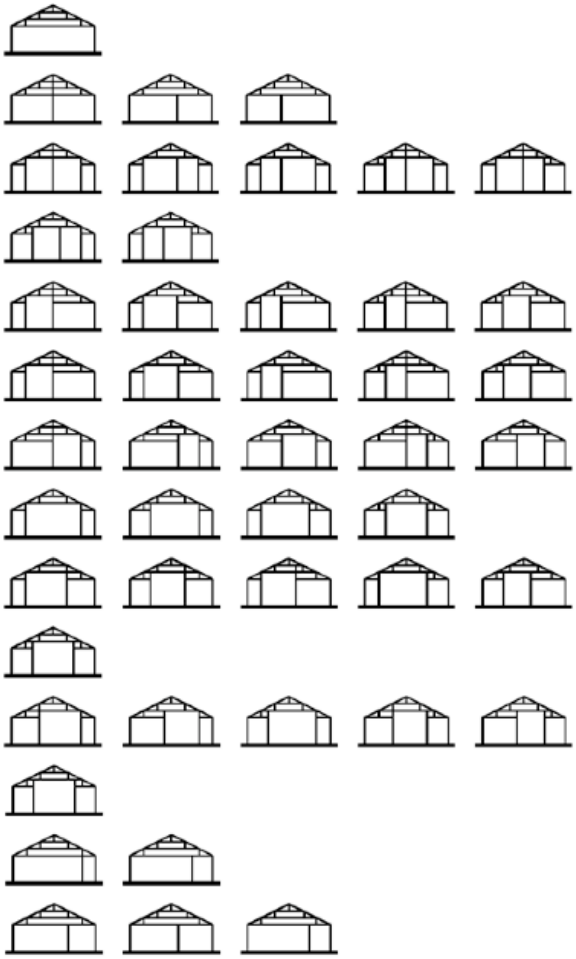


*Figure 5.* A language of sections with 47 designs.

A third invoked historical examples:

> I think that the whole process of making and modifying Constraint no. 1 is subjective because there is not enough information to support [my] idea. However, I think it can become more objective if we find more examples in extant buildings. (Tommy Lou Kai Chio)

## 6. Conclusion

The students began with the same corpus of designs, but ended up with markedly different conclusions about the larger language. This should not be surprising. As I have argued, extrapolating from corpus to language requires a standard of stylistic correctness that is objectively untestable and thus inherently subjective; conclusions vary necessarily.

In itself, this is neither good nor bad. What I have done is to articulate this point and the framework in which it resides, and to look for a way to use this framework in teaching students to understand a style. Hence the exercise of reconciling the language defined by a grammar and the language of stylistically correct designs as a way of developing a standard of stylistic correctness.

My strategy was to make the most of a grammar's abilities to structure a language of designs as a series of design choices (in other words, its rigor and generativity), and to do it in a graphically immediate way. Each rule communicated an action that contributed visibly to the design's distinctiveness.

To do this meant relieving students of those aspects of grammars which would have been distracting: deciphering control labels, executing deterministic sequences, even writing the working grammar. This I did by suppressing the deterministic or otherwise uninteresting stages of the grammar, expressing constraints verbally, and providing a working grammar.

These aspects are not necessarily negative in other circumstances, but in this context it would have been desirable to have some other alternatives for managing them. To these ends, further research is called for. Deterministic sequences, for example, certainly invite automation (Li 2002). As for constraints on rule application, expressing them verbally is intuitive but informal; it lacks the rigor that we expect in anything to do with shape grammars. There may be lessons for us from formal languages. And finally, although planning a process with two users is not unheard of (Knight 1999–2000; Chase 2002), the present scenario suggests that there are many ways to involve many users.

In this context, the grammar is less a machine for production than a means of articulating, manipulating, heightening our understanding of a

style; in short, it is a tool for thinking. We have long known that grammars can help us understand style. Now we see that they can respond not just to products, but to process as well. We can write grammars with subtlety and purpose to enhance our understanding of how we understand.

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