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Gabriela Goldschmidt [a]
[a] Architecture and Town Planning, Technion—Israel Institute of Technology, Haifa, Israel

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The Dialectics of Sketching

Gabriela Goldschmidt

Technion – Israel Institute of Technology

ABSTRACT: The generation of architectural form is by definition a creative activity. As a rule, architects engage in intensive, fast, freehand sketching when they first tackle a design task. This study investigated the process of sketching and revealed that by sketching, the designer does not represent images held in the mind, as is often the case in lay sketching, but creates visual displays which help induce images of the entity that is being designed. Sketching partakes in design reasoning and it does so through a special kind of visual imagery. A pattern of pictorial reasoning is revealed which displays regular shifts between two modalities of arguments, pertaining to both figural and nonfigural aspects of candidate forms at the time they are being generated, as part of the design search. The dialectics of sketching is the oscillation of arguments which brings about gradual transformation of images, ending when the designer judges that sufficient coherence has been achieved.

Freehand sketching is a common human activity, almost like writing. In everyday life, most adults and certainly almost all children are at least occasionally involved in the production of various kinds of sketches such as road-maps and plans, diagrams and abstract patterns as well as depictions of people, animals, and objects, real or imaginary. Most such sketches should be classified as 'drawings' which are representations of either direct percepts, or ideas and images held in the mind. Artists and designers are among the most ardent makers of drawings: In their professional capacity, they execute a great number of drawings as a matter of standard practice. Among these drawings, there is a special category of *study sketches* which architects have the habit of making in the very early stages of the handling of a task. These sketches, often scribbled on lightweight, transparent tracing paper, are usually made very fast and are sometimes so idiosyncratic that they are only comprehensible to their maker.

The purpose of the study reported in this article is to explore the process of making such study sketches. The practice of sketching is universal and dates back hundreds of years (ever since paper became a readily available commodity toward the end of the 15th century). If architects use the sketching tool so persistently, it must be very helpful to their thinking. The questions this study tries to answer are, What kind of reasoning does sketching represent?

Correspondence and requests for reprints should be sent to Gabriela Goldschmidt, Architecture and Town Planning, Technion– Israel Institute of Technology, Haifa, 32000, Israel.

Why is it so indispensable as a design-thinking aid? In the context of a design search, sketching is taken to be an a priori, inherently creative process, in that through it new artifacts are brought into being. To use common classifications of approaches to creativity research, it is the creative process that is here under scrutiny, not the creative product or the creative person (e.g., Gardner, 1988; MacKinnon 1970, O'Quin & Besemer, 1989). No measurement or quantification of manifestations of creativity are attempted. The intent is to point out what seem to be the inherent reasoning patterns in a domain-specific activity, namely the practice of sketching at the front edge of architectural designing.

Sketches as products have received exposure as steps leading to finished works of art or design, as illustrated by Arnheim's (1962) study of Picasso's *Guernica*. But the process of sketching has commanded little attention: Even the psychology of art has concentrated more on cognitive aspects of art viewing than on those of art making (e.g., Gombrich, 1960). Arnheim (1986) wrote about transformations in visual representation in the course of concept formation, but the making of sketches has interested researchers mainly as a developmental topic, and children's drawings are indeed the subject of many in-depth studies. Some of these works are of interest from the point of view of artistic development (Arnheim, 1975; Gardner, 1980); others look at graphic representation from a wider cognitive or developmental perspective (e.g., Beittel, 1972; de Bono, 1972; Goodnow, 1977; Karmiloff-Smith, 1990; Smith, 1979; Van Sommers, 1984). On rare occasions, methodological questions regarding architectural sketching have been addressed (Herbert, 1988), but little is known about the underlying specialized cognitive operations which go "beyond universals," to borrow Feldman's (1980) terminology. An exception is Fish and Scrivener's (1990) theoretical treatment of the cognitive mechanisms that are believed to enable sketching to induce artistic inventiveness.

The present study of sketching was part of a larger research project held at the Massachusetts Institute of Technology,[1] in which designers participated in "thinking aloud" sessions. These were recorded and then transcribed. The transcriptions, along with the sketches made by the participants (cross referenced with the verbalizations) comprise the protocols which served as data for the present studies. In the first round of exercises, seven experienced architects and one student of architecture worked on the design of a branch library.[2] A "footprint" (contour drawing) of a one-story, suburban library with six possible entry positions was presented to the designers, and they were asked to work on the entries and their consequences for the design of the library. Each individual session lasted between one and two hours, with the designers talking to an investigator, who only answered technical questions and prompted speech when silence lasted over several seconds. The data present a true challenge as protocols are usually and essentially

[1]The study was partially supported by a National Science Foundation grant #8611357-DMC. A first version of this article was submitted to the NSF as a technical research report under the title "Architectural Sketching: Seeing As and Seeing That" (1989).

[2]The 'Branch Library' design exercise was developed by William Porter of the MIT Department of Architecture. The designers' names in this article are all fictitious.

verbal, whereas in this case they are densely sprinkled with sketches. Although this raises certain methodological difficulties in the submission of the protocols to informal analysis (Ericcson & Simon, 1984), it is a worthwhile struggle, as it permits us to deal with "a real rather than a toy task," to quote Hayes (1989, p. 209), in his examination of another creative activity, that of writing. Informal analyses of creative endeavors have been carried out in other fields, such as poetry editing (Perkins, 1977). In architectural research there has been an effort to apply formal protocol analysis to the process of designing as a whole (Akin, 1986). That work is guided by Newell and Simon's (1972) information processing theory and looks at designing from a problem-solving perspective. The objective of the present study was to isolate the activity of sketching and use visual thinking and imagery as a conceptual framework for investigation. The entire process of designing, and its front edge especially, is not necessarily seen as a case of problem solving. A discussion of the difference between problem solving and other models of designing is, however, beyond the scope of the present discourse.

Designing: Moves and Arguments

To design is to plan for the making of something new. In the case of architecture, this "something" is an artifact of the physical environment. Designing entails generating, transforming, and refining images of different aspects of that still non-existent artifact and making representations of it which enable communication and examination of the ideas involved. The ultimate objective of the process of designing is the production of visual representations of the designed entity with enough completion and coherence to allow its construction or the construction of a visual simulation of it, physically or mentally. The questions we are concerned with pertain to the kind of reasoning that is employed in the course of experimentation and transformation, that is, the initial design search. To discover patterns of reasoning, if they exist, we must isolate and analyze the smallest units of design reasoning. This we do through parsing the protocols into design *moves*, and at an even finer grain, into design *arguments*.

Moves are the basic coherent operations detectable in designing, and arguments are the smallest sensible statements which go into the making of moves. Both *move* and *argument* are idiosyncratic terms. The notion of a move has acquired somewhat different meanings in different design studies (Habraken, 1985). In the present study, a design move is defined as an act of reasoning which presents a coherent proposition pertaining to an entity that is being designed. Argument stands for a rational utterance made by a designer, and bears on the designed entity or on an aspect thereof. The notion of moves and arguments is crucial to this study, and it is therefore important to clarify it. This can be done through an example.

Glenda is one of the designers who participated in the branch-library exercise. At a certain point in the process she assumed an urban setting with abutting buildings on either side of the library and divided the library site and building into a series of 9, and then 12 squares, which she identified as built and unbuilt areas. She darkened and left squares white respectively in her sketch (Figure 1). What she said next was assigned three moves in the analysis of the protocol:

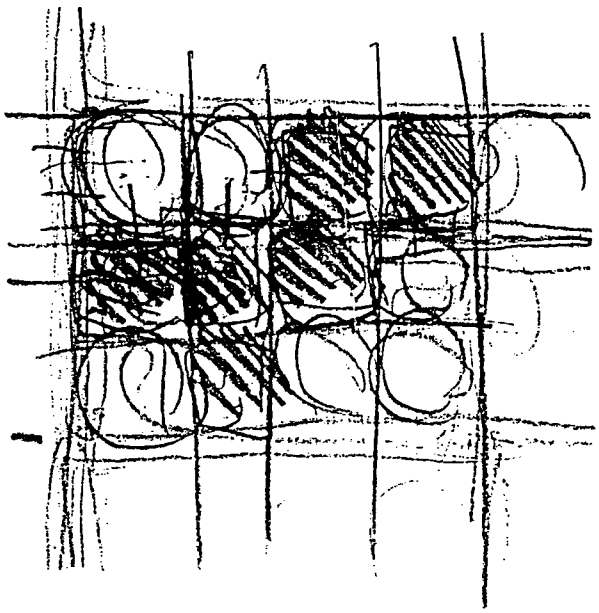

Figure 1. *Glenda's Sketch: Open (White) and Enclosed (Black) Spaces*

1. What you could do then is work on those squares as your basic element.
2. You could treat this as a puzzle sort of thing.
3. This does not seem to suggest any context for how it could get along with what's around it. For example, I can imagine this as a casbah [residential neighborhood of a traditional North African town, often a grid pattern of houses and their private courtyards. A common architectural reference] situation – not in Massachusetts... [but] where you have territories, confined territories.

The first and second moves contain one argument each. The third move is more elaborate and it was assigned three different arguments as follows:

3.i This does not seem to suggest any context for how it could get along with what's around it.
3.ii For example, I can imagine this as a casbah situation (-not in Massachusetts)...
3.iii where you have territories, confined territories.

The move advances the proposition that a casbah, with its confined (walled-in) territories, might be a suitable analogy capable of creating a context for tying the library to its surroundings. Subdividing the move into arguments shows that the proposition is gradually built up, in an additive sequence. First the designer observes that the pattern of squares previously established does not in itself suggest a unifying context that would facilitate the anchorage of the library to its built environment. Then the casbah image is brought up, with the reservation that Massachusetts is not where one would expect a casbah. Finally, the rationale for the analogy is spelled out: At the present state of the library design, its organization is based on a series of interconnected built and open (but enclosed) spaces, reminiscent of the organizational pattern of the casbah. Several moves earlier, the designer proposed to "treat it [the library] very much like a town-house" and after trying one town-house like concept she entertained the idea that "you could use the Chermayeff scheme for town-houses... with enclosed and open spaces as per need... ." Thus the casbah organization is made to fit in with town-houses which presumably would surround the library, if they happen to be based on the 'Chermayeff scheme' [Serge Chermayeff, a well known architectural theoretician during the 1960's and '70's] which used an organizational principle similar to that found in a casbah.

We learn from this example how intricate design reasoning is, as the trajectory the designer follows is not necessarily linear or hierarchical. There is no logical sequence of decisions which stem from one another, nor are concepts firm or even consistent at an early

phase (as the forced marriage between town-houses and casbah). Propositions may be uni-argumentative or multi-argumentative, and it seems that the sequence of arguments within a complex move is not critical. In well prepared protocols it is possible to indicate how each argument is associated to sketching (sketches are cross-referenced to verbalizations in the protocol). For the analysis of sketching, moves were classified as follows: moves made while actively sketching, moves made while contemplating sketches and reading off them, and moves with no graphic input. The three moves above were all made while Glenda contemplated the sketch depicted in Figure 1.

The protocols used in the present study were submitted to a structural analysis at the level of moves (Goldschmidt, 1989, 1990, in press). That analysis showed how much can be discerned regarding the systematic structure of design reasoning if relationships among moves are adequately identified and notated. The present study is a first attempt to work at the level of arguments, concentrating on the structure of visual reasoning while sketching.

Visual Thinking and Imagery

The importance of visual displays for performance in many tasks is widely recognized. Visual displays are not necessarily pictures: For example, it is easier to spell a complicated word when we see it written in front of us. The written word is a visual display though not a picture, in the sense that its meaning (and spelling) remains the same regardless of pictorial differences of style, color, or size of characters. Three dimensional models are frequently used in various design disciplines: They are not pictures either, but they certainly qualify as visual displays. In this study the discussion will be limited to actual pictures, or rather drawings.

Visual displays are particularly helpful in certain kinds of reasoning. In addition to providing direct access to explicit information contained in them, we may also see in them things which are not explicitly there. This may lead us to infer what we might otherwise not be able to tap. Following the footsteps of Gestalt psychologists, Arnheim (1969) argued that perception processes the information it gathers in a conceptual way, and as far as shape goes, perception is "the grasping of generic structural features" (p. 29). Elsewhere Arnheim (1986) elaborated: "Seeing a fire is always seeing fireness, and seeing a circle is seeing roundness" (p. 143). The ability to visually abstract from particulars and to typify information is useful in certain kinds of problem solving. A beautiful example is provided in Wertheimer's (1959) account of finding the area of a parallelogram. He presented a parallelogram to young children who did not know how to calculate its area, but who knew how to find the area of a rectangle. Children who saw a way to transform the parallelogram into a rectangle (Figure 2) succeeded in solving the problem. Visual strategies used to identify the relationship between the parallelogram and the rectangle which equals it in area differed slightly, but es-

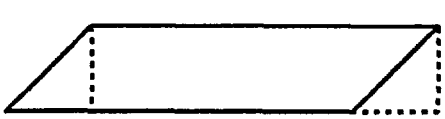

Figure 2. *Parallelogram Transformed into Rectangle (after Wertheimer, 1959)*

sentially they all hinged on an imagined subdivision of the parallelogram shape into smaller shapes that could be rearranged to create a rectangle.

The prallelogram problem differs from a design task in that problems are usually not prespecified in designing, at least not in a precise manner. They must be formulated by the designer. In defining problems, designers often use visual displays and their strategies are quite similar to those employed by Wertheimer's youngsters. Consider an example from our design protocols. Ben, an experienced designer, was trying to make sense of the shape he was given (the library footprint). Ben thought about organizational principles for the plan and for the better part of the session he treated it as a central area with three spaces, which he called 'pods,' attached to it. At one point he made these two consecutive moves:

1. Which is in fact the relationship that one would try to set up between all of those, between all of the three pods and the middle space? It seems reasonable to read it that way... hard not to.
2. What's funny is that I haven't been reading it as two L's back to back, which it also is. And you might read it that way if this were an office building... maybe I should anyway.

Figure 3 illustrates the two 'readings' of the shape that Ben generated: 3a is the footprint divided into a middle space with three surrounding 'pods' and 3b shows the configuration as two L's back to back. As in the case of the parallelogram, the moves made in order to get a handle on the problem or the task, consisted of adding imaginary lines which transformed a given meaningless or unresolvable shape into recognizable parts that were relevant, or promised to carry relevance, for the problem or task at hand. To be able to "see" the imaginary lines which subdivided the footprint and the parallelogram, Ben and the children had to employ mental imagery. Likewise, Glenda used imagery to 'see' the same footprint, and the rectangle in which it was bound when she had added site-lines, as subdivided into 12 squares (Figure 1). Imagery is central to visual thinking in all of its manifestations and is therefore of great importance to the study of designing. Without entering the question of neuro-activity of the brain at the time of image processing, it is important to clarify the philosophical difference between seeing and imagining. Wittgenstein's definition (from Anscombe & von Write, 1970) can be used as a guideline:

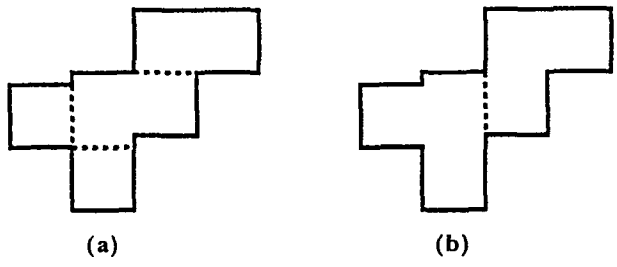

Figure 3. *Ben's 'readings' of the Library Footprint*: (a). *Central Space and 3 "Pods"* (b). *Two L's Back to Back*

> I learn the concept 'seeing' along with the description of what I see. I learn to observe and to describe what I observe. I learn the concept 'to have an image' in a different context. The descriptions of what is seen and what is imaged are indeed of the same kind, and a description might be of the one just as much as of the other; but otherwise the concepts are thoroughly different. The concept of imaging is rather like one of doing than of receiving... . (Note 637, p. 111)

Wittgenstein's emphasis on *doing* in imagery versus receiving in seeing is of

fundamental importance. Imagistic reasoning is based on recall of images previously perceived, and this capacity was used in the cases of the footprint and parallelogram: The rectangles and triangles into which these shapes were subdivided were recalled from inventories, in memory, of available and manageable shapes (squares, rectangles, triangles). For the parallelogram problem, this act of recall was sufficient to lead to a solution. Not so for the far more complex library footprint task: One or another set of adjacencies among rectangles did not directly lead to a concept that could be translated into a plan for the library. Complex tasks require a step-by-step generation of images. Indeed, Kosslyn, Pinker, Smith, and Shwartz (1981) asserted that images are not retrieved 'in toto' but are constructed from organized units. They are transformed in small steps, passing intermediate stages in the process. When first confronting a design task, in pursuit of coherent ideas, imagery is called on to assist in thinking, as is the case in other domains. Werner and Kaplan (1984) asserted that "... those who have reported on the process of giving form to new ideas and those who have reported on the struggles to make thoughts clear have generally mentioned the role of imagery in the initial phases of rendering thought explicit" (pp. 425–426). To generate a plan, even a simple one, and even when a shape is provided, as in the case of the library, is a complex task. Rather complex imagistic reasoning is likely to be required. This is where sketching comes into play.

Glenda's case demonstrates the complexity of the process. She came much closer to a plan than did Ben (as subsequent sections of their protocols assert), and getting there required several steps in which various images had to be represented and examined (puzzle, casbah, town-house), then interlinked (casbah and town-house), before a clear concept emerged. It is hard to imagine that she would have reached that point had she not employed sketching. Ben did not engage in sketching, but only contemplated a drawing while suggesting back to back L's. What is it that happens when one sketches, and why is it so helpful to sketch when starting to design? Let us first listen to perceptions offered by another two of our designers (the commentaries were made as part of on-line verbalizations: No direct questions were asked):

> When I sit down to work, it's hard... to have a sort of steady stream because oftentimes... it takes you a while to isolate enough of the pieces a way that you can actually work on some piece of it. When I first start, I make a lot of drawings. I don't understand what I'm doing until I draw it a few times, and then it becomes clear to me what I'm trying to do, and then I can begin to work on it... It is important as a designer to perceive the form in space while you are trying to get at the ideas.

> I can't get very far with just thinking about it without drawing something... I tend to overlay when I use pencil... they [overlays] are usually pretty similar... these drawings are usually worthless as products so I am not very attached to them... I also do a lot of erasing. I like to erase because I like to have a lot of lines on the page. I like fuzzy stuff. I can see things in it more than I can in harder-lined things. So, sometimes I just get a lot of lines out and then I start to see things in it. A lot of times I pick up things I think are important. I put down potentials and then erase down to them... I'm learning to erase less and just overlay... .

A novice designer (first year architecture student), added her perspective:

> I don't know [whether an experienced architect would approach the task differently], because I don't know if he [experienced architect] would

> look at this and immediately see these and wouldn't even have to draw it for himself because he can see it. I felt I had to stop and... actually draw out for myself what I'm saying in words.

What is it that we must infer from these insightful remarks? And how can we relate them to imagery?

Given that an entity to be designed or that is being designed does not yet exist and therefore was never perceived, it cannot, in its entirety or its parts, be recalled or imaged in the normal sense. How then does a designer start? He or she starts by generating partial images of tentative aspects of the designed entity. Such images may follow recollections of existing buildings or artifacts which serve as references; they may find their origins in precedents derived from metaphors, analogous cases, or entities belonging to a similar type. To elicit a suitable image or a range of images to choose from and to build on is so complex that it can hardly be done all at once and must be undertaken in stages. Through sketching one prepares an array of displays of shapes and relationships among shapes that enrich the designer's search-space because they harbor both expected and unexpected images. Beittel (1972) reported a similar process in artistic endeavors: "In the on-going artistic dialogue, the line which creates on a pregnant ground gives way to the remaining ground opposite it, which evokes a new contrasting figure" (p. 26).

Almost any display may provide clues that could lead to potentially useful images, as testified by the above quote from one of our designers: "I like fuzzy stuff. I can see in it more than I can in hard-lined things." An appropriate display goes a long way, as demonstrated by Wertheimer's parallelogram. The advantage of sketching is its dynamic nature: A sketch may be transformed by adding to it, by deleting parts or by drawing over it. The designer is not confined to a single sketch: He or she may generate as many sketches as required before satisfactory images emerge, and thus "When I first start, I make a lot of drawings. I don't understand what I'm doing until I draw it a few times, and then it becomes clear to me what I'm trying to do... " A series of sketches may be produced as a continuum or as a spotty collection of diverse images. Either way, the designer searches, as the quotations above cogently express, sufficient relevance and coherence of images to permit the maturation of a plausible representation of the designed entity or, more likely, aspects of it. In relating his experience as an inventor, de Bono (1971) told about a deliberate 'hunt' for clues in relatively random visual displays until something was perceived that triggered an idea. Sketching achieves a similar goal, but the search is not random and it does not stop when the idea is triggered but continues in order to develop, test, and refine it. The old Italian name *pensieri* that was given to sketches when sketching first became a common practice in the art and design world of the Renaissance, means 'thoughts' (Olszweski, 1981). The name most appropriately describes sketches, which are indeed thoughts. Accordingly, sketching is thinking. The search cycle ends when the designer is ready to attempt a 'hard-line' drawing (more or less accurate, true to dimensions scale drawing, often executed with drafting devices such as rulers and triangles). Its purpose is to test and verify a concept through a communicable representation.

Not all designers sketch extensively,

and some refrain from sketching altogether. According to his own testimony, Frank Lloyd Wright processed images in his mind and never touched paper before they were brought to completion entirely in his head; he also recommended that other designers follow suit (Kaufman, 1955). Most designers, however, seem to ignore Wright's recommendation and practice extensive sketching (likewise, most composers write and rewrite their scores with many revisions and transformations, unlike Mozart who claimed to be hearing an entire composition in his 'mind's ear' before he put down the notes in one spell, with no gaps and no revisions). What most designers do is to draw and re-draw lines, shapes, objects, and "fuzzy stuff," until they can 'read' in, or off what had been drawn, something useful. We call this operation *interactive imagery*: the simultaneous or almost simultaneous production of a display and the generation of an image that it triggers. Sketching, then, is not merely an act of representation of a preformulated image; in the context we deal with, it is, more often than not, a search for such an image.

Seeing As and Seeing That

In the controversy over the nature of mental-visual imagery, pictorialists hold the view that images represent the way pictures do. In this view, imagery is pictorial, or analog (nondigital). Descriptionalists, on the other hand, believe that mental images represent in the mode of language rather than pictures. Hence imagery is discursive or descriptional or propositional (Block, 1981). There have been voices that claimed pictorial and discursive imagery to be impossible to separate. Fodor (1975) referred to "images under description" and Kosslyn et al. (1981) concluded that image construction can exploit nonpictorial as well as pictorial information. Recently an experiment in metal rotation led Takano (1989, p. 20) to assert:

> It is impossible to decide *strictly* whether a given representation is 'analog' or 'propositional'. What could be done would be, at best, to judge whether the given representation would look more similar to certain prototypical 'analog' representations or to certain typical 'propositional' representations... [but] even a prototypical 'analog' representation would be able to behave just like a prototypical 'propositional' representation if coupled with appropriate processors Andersen (1978).

Sketches are obviously pictorial, for they refer to shape and orientation, and often to approximate size even if they maintain a varying degree of abstractness. Yet it is impossible to confirm that there is a direct one-to-one correspondence between shapes and figures on paper and the images they stand for. It is therefore proposed to refer to the (pictorial) reasoning evident in interactive imagery at the time of sketching as consisting of two modalities. The designer is *'seeing as'* when he or she is using figural, or 'gestalt' argumentation while 'sketch-thinking'. When *'seeing that'*, the designer advances nonfigural arguments pertaining to the entity that is being designed. The process of sketching is a systematic dialectics between the 'seeing as' and 'seeing that' reasoning modalities. To examine this proposition, design moves and arguments were inspected as they are established through protocol analysis. The notion of 'seeing as' and 'seeing that' will be further elucidated as we proceed, so as to best exploit documenta-

tion from the protocols. Consider once more the excerpt from Glenda's protocol quoted earlier. Each argument is now coded, using the 'seeing as/seeing that' classification. The arguments made by Glenda are reprinted here with their codings:

1.	**THAT**	What you could do then is work on those squares as your basic element.
2.	**AS**	You could treat this as a puzzle sort of thing.
3.i	**THAT**	This does not seem to suggest any context for how it could get along with what's around it.
3.ii	**AS**	For example, I can imagine this as a casbah situation (not in Massachusetts)...
3.iii	**THAT**	Where you have territories, confined territories.

Glenda sees *that* the squares could be treated as basic elements. The square-configuration could be seen *as* a puzzle. She sees *that* this metaphor leads nowhere. She tries another metaphor: Seeing the square pattern *as* a casbah. She sees *that* in a casbah there are confined territories. In this short passage the designer alternates her reasoning modality with every new argument she makes. Figure 4 is a graphic notation of the argument sequence in terms of the 'seeing as' and 'seeing that' coding.

In the short sequence examined above, a pattern of alternating as and that arguments suggests itself. Whether this pattern is typical, and to what extent, must be established on the basis of a more extensive investigation. Sections from three other protocols of the library task, all marked by intensive sketching, were selected for investigation. In two of the cases the analysis relates to several quick sketches which the designers, Ronna and Gilbert, produced sequentially. In the third case a single sketch was developed by Martin for a longer period of time and brought to fruition in terms of the design task (seeing that we deal with the front edge only). Because the data are extremely rich in this case, it is presented in detail so as to obtain an anatomy of the design process through the activity of sketching. As will be shown, a 'seeing as' and 'seeing that' codification of the arguments in this case yields a pattern very similar to that found for the cursory example above. The two other cases under investigation produce similar patterns, although they are not as unequivocal.

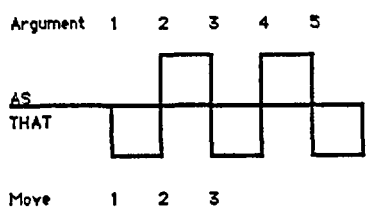

Figure 4. *Seeing As and Seeing That Arguments in Glenda's Protocol*

Martin's Branch Library

Martin, a famous European architect and frequent guest teacher and lecturer in the U.S.[3], was uneasy with the task from the beginning. He had two objections: First, he found the library footprint quite appalling. "I would come up with another plan, that's

[3]Martin, a brilliant architect, has the reputation of being a particularly creative person. A certain bend toward the investigation of the creative personality must therefore be admitted. However, issues or data pertaining to Martin's personality or design contributions over time are not discussed here. Looking at his designing/sketching performance in isolation in the framework of the library exercise and comparing it to that of other architects who have dealt with the same task, sets the context of this investigation in the realm of the creative *process*.

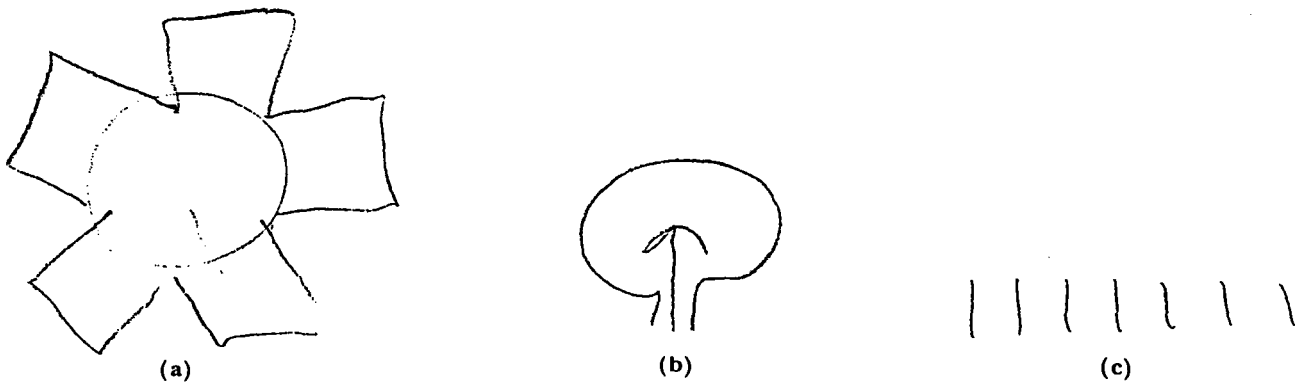

Figure 5. *Martin's Diagrams Describing Spatial Organization:* (a). *Serial Elements*, (b). *Central Organization, and* (c). *Linear Sequence*

for sure," he said. Second, he thought it impossible to work without a specific site. He explained: "... I feel powerless, because I think architecture is the organization of space in three dimensions, but related to a location, to a situation. ... I have to be in confrontation with a site, with a situation... If I don't know the orientation, it's very difficult... " He finally agreed 'to play the game': "I would not make a plan like that, but once it exists, I accept to organize the thing... ". The analysis below covers a preliminary phase, then moves on to follow his reasoning while producing his final sketch. It is that later phase that is submitted to the *as/that* analysis.

Martin started by sketching and articulating in length various possible principles of spatial organization: Space as a series of elements, such as rooms, in some geometrically coherent configuration (Figure 5a), a central organization, with a strong focal point (Figure 5b), and a linear sequence of repetitive elements, like houses or rooms, elsewhere called 'adjoining cells' (Figure 5c).

How would such organizations be achieved? By way of introducing a center, an axis, a direction, an orientation. The goal is to advance a spatial idea: "to give a spatial reference point" which would serve as "a key for reading the space." The given footprint, on the other hand, "is the opposite of space"; it is "like a labyrinth" (Figure 6).

Having expressed his reservations, Martin was willing to approach the design exercise. Relating to the six possible entry points, he asserted that no entry is superior to another and no organizational rule is best a priori. For each entry a suitable design solution can be worked out. To prove it he made a few quick sketches of what the footprint would be like if one used either one of three different entrances (Figure 7). In all three instances Martin divided the footprint into three zones. A central part is accessed from the entry and continues across the structure, where a control point for the library is located (accommodating the librarian, for in-

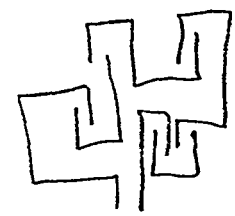

Figure 6. *Martin's Diagram Illustrating a Labyrinth*

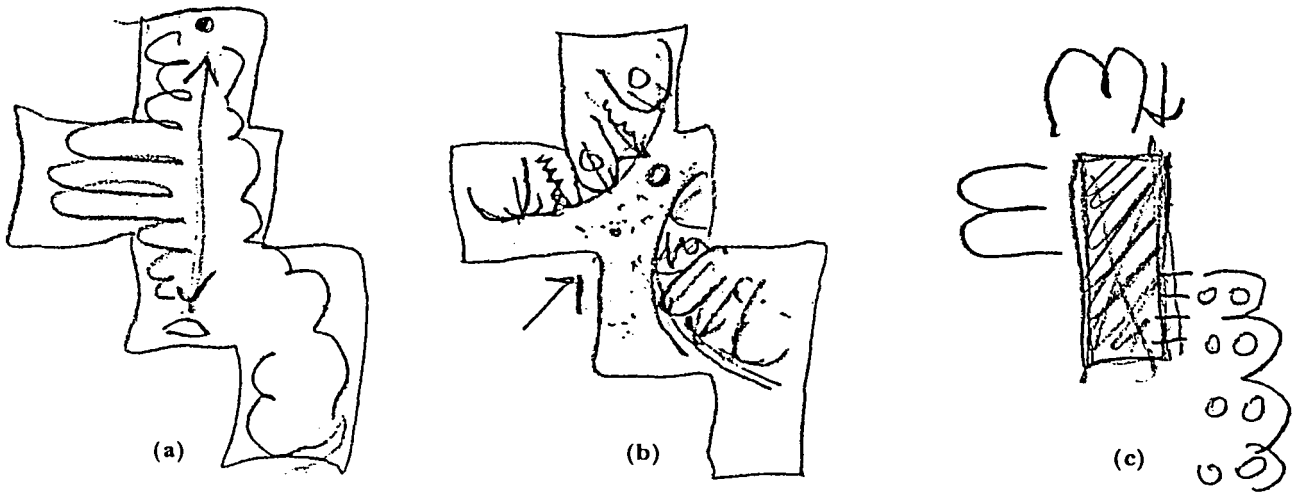

Figure 7. *Alternative Library Plans Using Different Entry Points:* (a). *Long Entry Hall Between Reading Rooms and Stacks,* (b). *Open Plan With Interior Court, and* (c). *Library Elements Surrounding Atrium*

stance). The two zones on either side of the central space are to house stacks and reading rooms respectively. Each scheme offers a different spatial idea. The scheme depicted in Figure 7c, for example, was described as a central atrium connected to several separate sections, whereas in the plan in Figure 7b there would be a minimal number of interior elements, all of them open, so as to sense the simplicity of the entire space immediately upon entry.

It was not until much later that Martin undertook to 'really' design the library. But before we look at what he did then, let us stop for a moment and ask ourselves what he had done thus far.

He started by pointing out what the footprint is not: It is not a good space because it does not have a center, an axis or a direction. What was it that Martin perceived, and what did he see? The form in front of him, he said, did not have certain properties. Can one see negation of properties? The answer is yes and no. One cannot see an entity *as* not being something. One can only see what is there, which may or may not be *as* something else that shares some of its properties. But one can see *that* an entity does not have those properties. For example, we can see this sheet of paper *as* being white. We can also see it *as* being pink (at sunset, say), but we cannot see it *as* being nonwhite or nonpink because this would yield endless possibilities, whereas we only see it at a given time as a single display, which (in this case), has one color to it. If we do not see the sheet of paper *as* white, we can nevertheless say *that* we see that it is nonwhite, without committing ourselves to a color.

Martin saw *that* the footprint did not have the qualities that in his view would make it a good architectural space. He also saw it *as* a labyrinth, an entity which, because of its pronounced lack of center, direction, axis and so on, became a symbol of 'antispace' in Martin's discourse. We may conclude that in this first phase Martin reasoned about the footprint by seeing it both *as* something undesirable and by seeing *that* it does not have certain positive properties.

Having criticized the given footprint, Martin began to interact with it. In each of the three schemes he drew, he saw it as divided into three zones, conceived differently each time as open or contained spaces. The central entry space in all three sketches is spacious and reaches from one face of the building to another. Did Martin see that a central space or an entry space, in a branch library, or in any building type, should possess these characteristics? We do not know. But about the atrium (Figure 7c) he told us: "I should get to know the functions better... Maybe there is no need [for an atrium], in which case I couldn't make it; I would have to find something else." We may say that Martin sees *that* an atrium may be appropriate. However, he sees the footprint not only as harboring an atrium, but *as* possessing "an atrium like this." Like what atrium? Like the one he drew. It would have been difficult to imagine Martin reasoning about the library footprint the way he did, had he not executed the three sketches of Figure 7. Unlike the previous diagrams, they were not made just for the investigator. Through them he established what could be done with the footprint if it were to be entered through various entry points. What could be done hinged on seeing *that* there should be three sections and each section is seen as open or contained or as an atrium or as a reading room and so on.

Following these sketches Martin discussed in great length some of his design values and beliefs in a most general and abstract way, interspersing the discourse with examples from his experi-

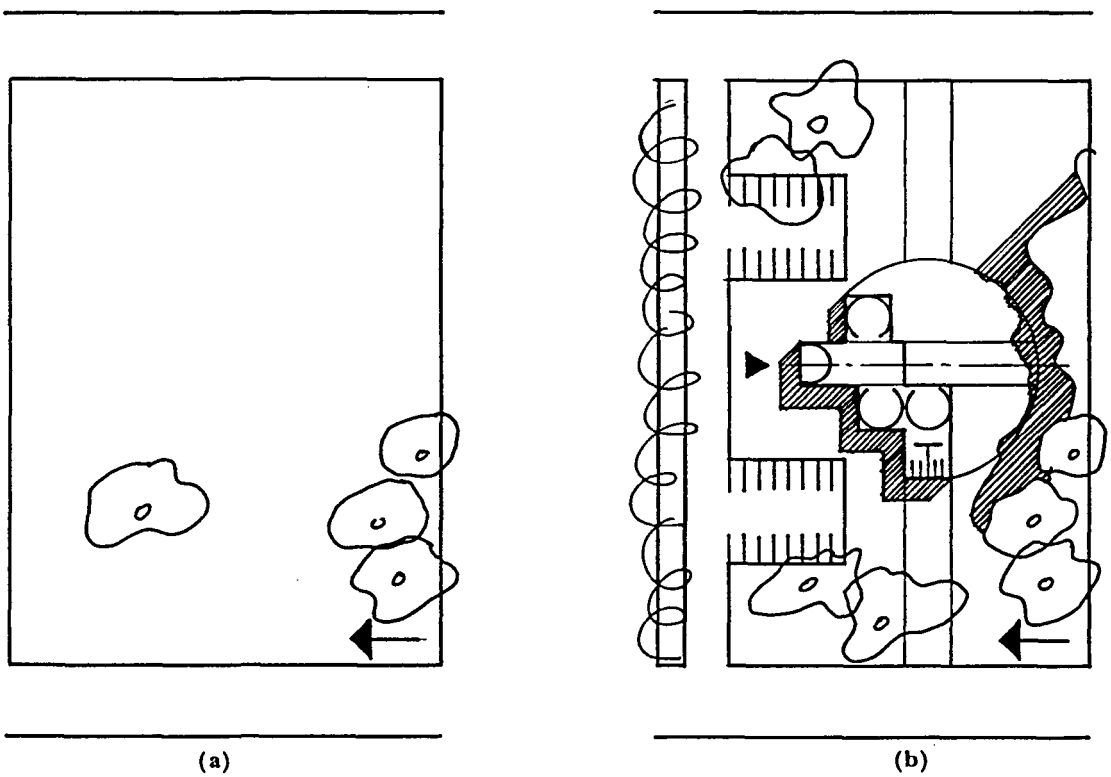

Figure 8. (a). *"Site plan" Given to Martin by Investigator, and* (b). *Reconstruction of Martin's Design*

ence. He finally returned to the footprint, but not before the investigator provided site conditions: orientation (an arrow indicating north), lot lines with streets on two opposite sides, and a few large trees on the site. A reconstruction of that plan is depicted in Figure 8a. Martin laid the 'site plan' over the footprint drawing and within a few minutes accomplished a design, working on a single sketch. Figure 8b is a reconstruction of his drawing and the sketch itself is reprinted in Figure 9. We shall want to inspect Martin's sketching activity step by step so as to examine his reasoning closely. But in order to better understand his moves and arguments, a postfactum analysis of the resultant design is presented first. The parsed protocol (see Appendix A) as well as the commentary below are cross referenced with the sketch in Figure 9.

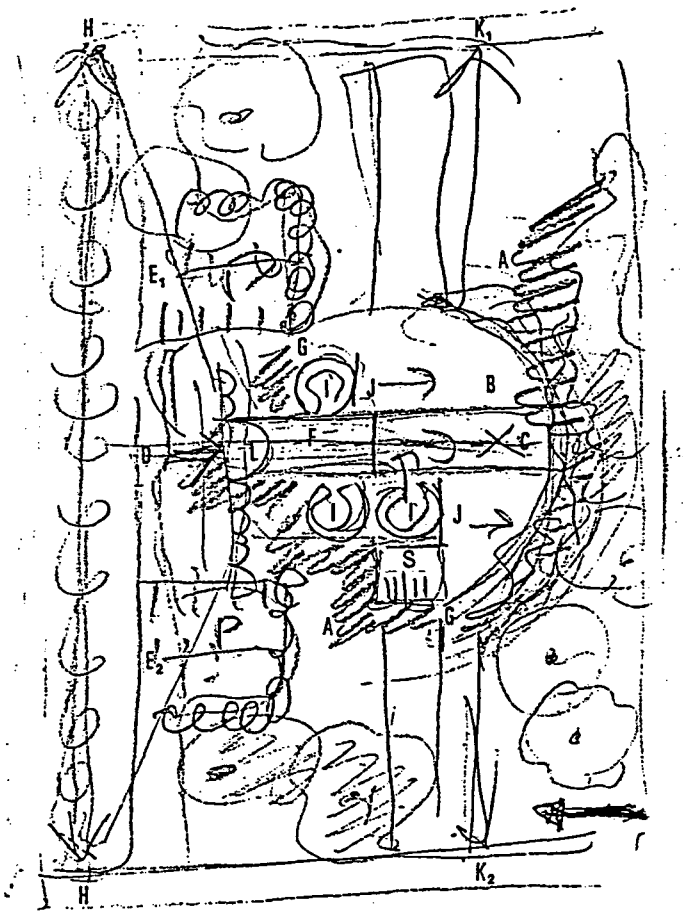

Figure 9. *Martin's Sketch (Cross Referenced to Verbalizations)*

The scheme encompasses the entire site and ties the building to its immediate surroundings in an inseparable manner. The site is accessed from the two streets **[H]** via an internal driveway. Along it are two parking lots **[E_1, E_2]**, on either side of the building. The entrance to the library **[D]** is midway, across the driveway. One enters along an entry axis **[F]** which runs through the building and across an outdoor space which is its extension **[B, C]**. That outdoor space is enclosed by big, shadow-casting trees **[A]** along the lot-line. Some of these trees were on the site drawing, others were added by Martin. Inside, the entrance space is marked by a semidome **[L]**. Three similar spaces **[I]** contain the main library functions, one east of the entry space and two west of it. A single spatial module further to the west is dedicated to services **[S]**, namely rest rooms and the like. More large trees were added and shrubs are indicated along site features like the driveway and the parking lots.

The integrity of this design and the speed in which it was achieved are astonishing. No other designer in the library experiment has developed a plan as comprehensive as this one, paying attention simultaneously to so many different design issues (eg., visibility and prominence of entrance, inside-outside relationship, hierarchical space adjacencies, site development). How did Martin do it? Having examined what preceded this sketch, it is not difficult to explain how things came together. Martin al-

ready established that he wants a center, a direction, an axis. Adjoining cells are fine by him. He explained earlier that the organization of a building should strongly depend on its relationship to the site. It also became clear that in Martin's immediate repertoire, a branch library (or at least this one), seems to consist mainly of a spacious entry-space which runs across the building and two zones for library functions. All of these things are present in the new sketch; it looks so self evident that we wonder why he refused to puzzle the pieces together into a whole before the site plan had been handed to him. But this is exactly the point: He needed to go through the clueing process which was made possible only once he confronted the display provided by the site-plan. Then he was able to use interactive imagery, through sketching, to see that things fall into place because they could be seen as familiar substances, desirable for his purposes.

Martin's protocol was analyzed by parsing it into moves and arguments and by codifying the arguments according to the 'seeing as' and 'seeing that' modalities. The complete analysis can be found in Appendix A. As in Glenda's case, the results were graphically notated. Similar notations were prepared for protocols of the two other designers, Ronna and Gilbert. The notation, in Figure 10, differentiates (at the level of moves) among active sketching, contemplation of a sketch and reading off it, and acts of reasoning with no direct graphic input.

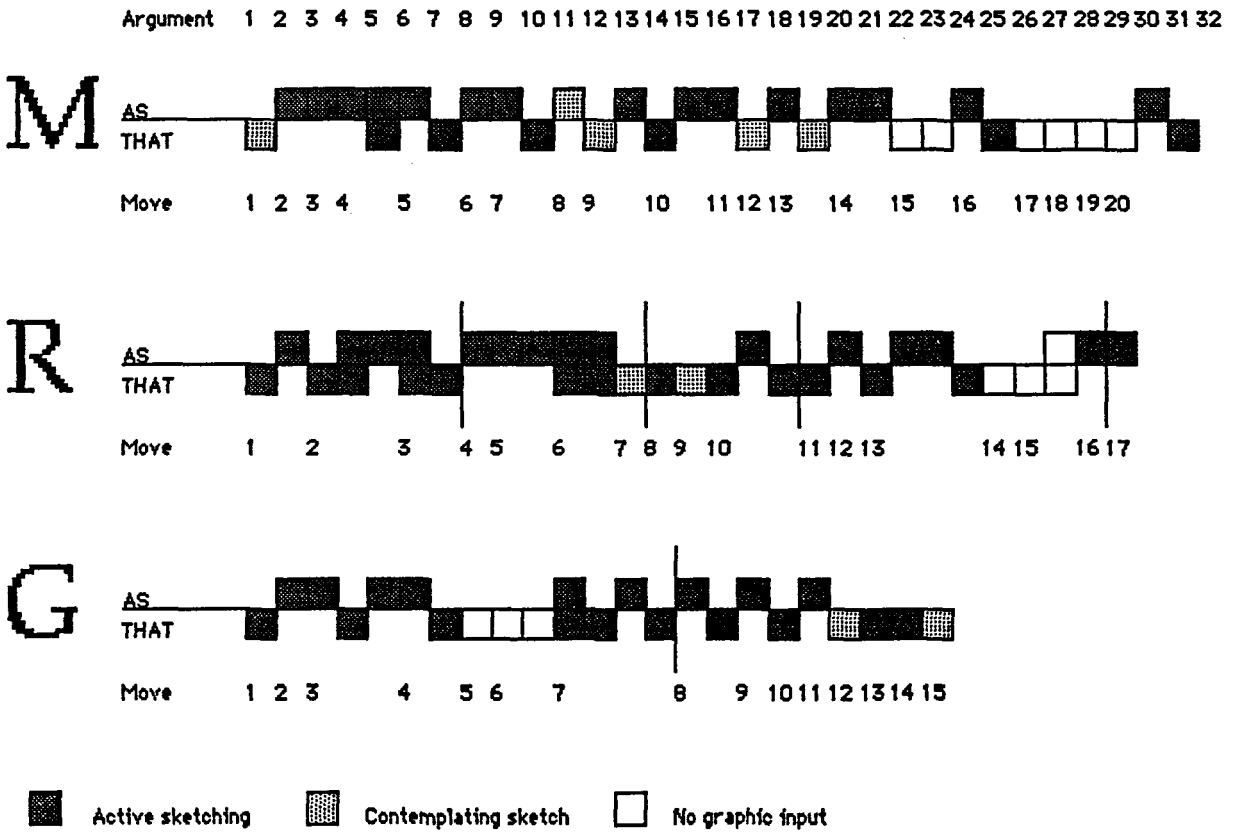

Figure 10. *Notation of As and That Arguments (Martin, Ronna, Gilbert)*

Figure 10 reveals a most coherent pattern. Let us first look at Martin's notation. Half of the arguments (15) he made qualify as 'seeing as' arguments, the other half (15) are 'seeing that' arguments, and one (argument no. 5) is a 'seeing as/that' argument (a joint coding, assigned when it was impossible to take the two modalities apart). For the most part, 'as' arguments are preceded and followed by 'that' arguments and vice versa. All 'as' arguments, with a single exception, were made while sketching. 'That' arguments were made both while sketching and while pausing to contemplate on-line sketches.

In comparison to Martin's graph, Ronna's graph displays less 'as-that' shifts of single arguments. Groups of arguments, though, do shift from the 'as' mode to the 'that' mode repeatedly. She too made almost an equal number of 'as' arguments (10) and 'that' arguments (13). Six more are mixed. Gilbert made more 'that' arguments (14) than 'as' ones (8) in addition to one mixed argument. In his graph both individual arguments and groups shift modes between 'as' and 'that'. Based on these results it is proposed that design reasoning at the time of sketching is characterized by short sequences of arguments which shift between *seeing as* and *seeing that* modalities. Shifts occur both within moves and across moves in a cyclic manner, which we call the *dialectics of sketching.*

The Dialectics of Sketching

Two questions must now be asked. First, what is significant in the pattern just outlined? Second, is this pattern of reasoning modular (Fodor, 1983)? That is, is it unique to designing while sketching only?

The regularity in which design arguments shift reasoning modalities, as depicted in Figure 10, is no coincidence. In its purest manifestation, the oscillating pattern reveals itself in moves containing two arguments, one of each modality. There are two possible sequences: first 'as' then 'that', or vice versa — 'that' first, followed by 'as'. Let us examine two examples from Martin's protocol, move 10 and move 13 (see Appendix A). In move 10 he tells us that he wants an important element, then he states that he sees the axis he had introduced earlier as such an element. In move 13 he first sees some of the walls of the library as being 'open' (e.g., glazed), then he explains that this would achieve the prolongation of the axis (into the outdoor space). In each move the two arguments are strongly interlinked and we can assume that the first led to the second, or at least contributed considerably to its generation. In both cases, one of the arguments is directly extracted from Martin's generic design theory, or codex of design rules, some of which he explicated earlier (the strength of an axis as an organizing principle, the importance of a relationship to the site and its features). But in both cases these 'rules' are applied to the task at hand in a unique way, through making or transforming visual displays which were non-existent before their creation by Martin during sketching. In the first case the rule (important element) led to a feature of the designed entity (axis); in the second case the physical feature (glass walls) elicited a rule (prolongation of axis) which justified it.

Hence, the order in which arguments switch modalities is not important. What is significant is the fact that

the shifts occur both ways. Arnheim (1986), following Wittgenstein's (1953) discourse on this matter, recognized the role of 'seeing as' in visual thinking and formulated the underlying principle which governs its role in reasoning: "... all perception is the perception of qualities, and since all qualities are generic, perception always refers to generic properties" (pp. 142-143). What is added here is that when we do more than integrate information through perception, producing physical representations of something in the course of its making, it is unlikely that results could be achieved by inducing from particular properties to generic qualities alone. Instead, a dialectic is suggested, a back and forth swaying movement which helps translate particulars of form into generic qualities, and generic rules into specific appearances. When these operations are iterative we can assume that over a sufficient number of cycles, enough transformations may take place to facilitate a good fit between the components of what is being created. By no stretch of the imagination can it be assumed that so many transformations can be achieved without a constantly changing, self-updating display. Sketching exploits interactive imagery to provide such displays. Fish and Scrivener (1990) reached a similar conclusion in their analysis of sketching by artists. They wrote: "We posit that sketches have the important function of assisting the mind to translate descriptive propositional information into depiction. This descriptive information may then be scanned by attentional processes to extract new and perhaps original descriptive information, which in turn can lead to new depiction" (p. 118).

Irregularities such as uni-modal moves (i.e., in moves containing more than one argument) and somewhat longer sequences of same-type arguments across moves, are variations on the basic regular 'pendulum' pattern and may result from a number of reasons, such as differences in personal styles of reasoning or the design phase in question. Small irregularities in otherwise regular reasoning patterns may be expected at moments of discontinuity resulting from uncertainty, new inputs, and the like. Another major cause for an inconsistent pattern may be the nature of the task. Different tasks may require different strategies of confrontation with the material. Yet another important cause has to do with the designer's level of expertise. Less skilled designers cannot 'ping-pong' arguments across modalities as can experienced and expert designers. In another study (based on the same protocols), a correlation was found between expertise and the systematic structuring of design reasoning (Goldschmidt, 1989). It is not clear whether an unequivocal match can be established between 'general' design reasoning and the dialectical reasoning manifest while sketching, but it is not unreasonable to assume that some correlation does indeed exist.

As to the question of modularity, or uniqueness of the particular dialectics of sketching, only a tentative answer can be attempted here. A dialogue, or dialectic, is by no means specific to designing. Likewise, 'seeing as' and 'seeing that' are not unique to sketching, nor to architectural or other kinds of designing, as Wertheimer's parallelogram problem proves. As general concepts, these terms provide insight into various psychological and cultural phenomena. The history of religion, for ex-

ample, may illuminate the disparity between Catholicism with its taste for liturgical worship and Protestantism, with its preference for preaching, by using the concepts of 'seeing as' and 'seeing that' (M. Heyd, personal communication, December 16, 1989). The use of physical metaphors in all disciplines entails 'seeing as' and in design, in science and in art there are many examples of metaphors which led to new developments and to important innovations, discoveries, and inventions. The question is one of scope and scale. This investigation did not attempt to elaborate on concepts and their evolution, but on small-scale creative cognitive operations in reasoning while fulfilling a domain specific task. Protocols reflecting reasoning in the course of carrying out a task other than designing were not yet analyzed, but design protocols with little or no sketching were inspected (such as Ben's). In those protocols arguments of both kinds were found, but 'seeing as' arguments are by far a small minority dispersed among a vast majority of 'seeing that' arguments. The extended 'ping-pong' pattern between *as* and *that* arguments that was discerned in the 'sketching protocols' was detected nowhere else.

In conclusion, it is proposed that sketching introduces a special kind of dialectics into design reasoning that is indeed rather unique. It hinges on interactive imagery, by a continuous production of displays pregnant with clues, for the purpose of visually reasoning not about something previously perceived, but about something to be composed, the yet nonexistent entity which is being designed. When working without sketching, or when generating abstract displays, such as diagrams or flow charts, visual thinking takes place and the same reasoning modalities come into play. However, they are not organized in the dialectical pattern we have unveiled, at least not for any length of time. Such visual thinking is of course useful and productive, but it is not typical of form-making phases in designing or otherwise. The inherently creative process of form-production, then, at least in architectural designing, seems to result from a special systematic, causal relationship between two modalities of visual reasoning, induced by sketching.

Appendix A

Martin's Protocol: Seeing As and Seeing That Arguments
• Move with active sketching © Move while contemplating sketch and reading off it
(See Figure 9)

1 ©	Trees mean shadows and that is important.
THAT	"That [trees] means shadows [A]. It's important enough."
2•	The importance lies in the space that this creates.
AS	"It's important enough because there [B] one starts creating a space."
3•	Would attempt to make this space a prolongation of the building.
[AS]	"I would try to make this [C] a prolongation element."
4•	People can approach the building by walking through car parks, from both sides of the site.
AS	"I would make the entry [D], one can come through the cars [parking] here [E_1];
AS/THAT	it's the case of the other side as well [E_2]."

5• Give the entry area a more geometrical character, a reference point.
AS "So as to... Something more geometrical [E-D-E].
THAT Create a point of reference."
6• The tree-enclosed space should be more organic.
AS "There [C], on the contrary, more organic, toward the exterior."
7• Would put the entrance here, coming from both sides, because it is easy to arrive from the two parking lots.
AS "Personally, I would put the entrance here [D].
THAT [There is access] From both sides, because there is the parking there; the ordeal of parking. It's much easier to enter."
8• A hierarchy emerges: The large trees, the parking lots, pedestrian access and an entry axis.
AS We start creating a hierarchy:... The large trees, the parking lots, the pedestrians, an entry axis [F]."
9• Would look for a direct entry-outdoors relationship, because the real edge [of the building] is the trees.
THAT "I would then look for a direct relationship between entrance and exterior,
AS because here, the real edge is not this [G], for me it's that [H]."
10• I would like an important element and would therefore create the afore mentioned axis.
THAT "I would try to have an important element;
AS would therefore make the axis I mentioned before, this one [F]."
11 © These elements [spaces in the footprint] begin to be 'adjoining cells'.
AS "These [I] begin to be elements of 'adjoining cells'."
12 © Would also start to lend importance to the exterior.
THAT "... and I would try to make important also the exterior."
13• The walls toward the exterior space can be open, to prolong the axis.
AS "So these [J] can be open, here.
THAT To prolong that axis, there."
14• Would organize the library with three niches and reserve the forth, remote one, for service only.
AS "And I would probably organize the library with these three niches [I]
AS and I would keep that as a service-only element [S]."
15 This is a way of letting elements of nature into the project; doesn't like isolated buildings.
THAT "So this is a way of letting elements of nature into the project.
THAT I don't like isolated buildings."
16• The building should extend from one edge of the site to the other. Through this organization space may reach these boundaries. It would create tension, prolongation. This is not a little shed; it is a different approach: This organization is beyond functions or interior organization.
AS "The building needs to reach from here [K_1] to here [K_2].
THAT I would try through this organization to make space reach until there, so it has tension, it has a prolongation. It isn't a small shed, it isn't a pavilion on the interior. There. This is a different approach, but already, these elements there have found a different organization, and beyond functions, beyond, I would say, the interior organization."
17 © This building doesn't just have a door; its real elevation extends from street to street.
THAT "The building doesn't just have a door; its facade goes from here to here [E_1-E_2]. This is the real facade."
18 Would use the parking lot organization to reinforce this idea of incorporating the entire site.
THAT "So I will make the organization of the parking lots give force, with the trees, to this idea. I always want to take the entire, all of the land."
19 © Since there are two man-made roads, it is justified to structure the whole ensemble rather than let the pavilion float in the midst of the site. The discourse becomes one of exterior considerations.
THAT "I think that if there are two roads, there is already something artificial... drawn by man. I find it justified to master the whole. Not let the pavilion swim in the middle. So you see how the discourse becomes immediately one of exterior."
20• Inside, would now impose a hierarchy. The entry space could be domed; the side elements should be smaller so as to sense the hierarchy. It is a question of space rather than of mere dimensions.
THAT "... so I would give a hierarchy;
AS this [L] could become a dome, these elements on the side [I] - a little smaller,
THAT so as to feel the hierarchy. Because it isn't just a dimension, but a space."

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