

SKETCHES AS COGNITIVE TRACES: ALVAR AALTO AT IMATRA *

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Abstract. While architectural historians have often noted the connection between design sketches and finished buildings, to date there has been little in the literature that relates these drawings to discoveries in neuroscience and visual perception. This essay presents an analysis of the drawings of the great Finnish architect, Alvar Aalto, suggesting how researchers might begin to unlock the mental habits of architects and designers to discover historical patterns of thought.

Drawing on previous research that traces what I have called “modes of conception” among prominent architects, the paper analyzes the connection between drawings, cognitive patterns, and memory in the work of Aalto, one of the most influential architects of the twentieth century. Because many of his sketches survive, along with detailed biographical and eyewitness accounts of his practice, it is possible to study Aalto’s cognitive patterns in detail.

The essay begins with a hypothesis about the relationship between external memory triggers, or “exograms,” and drawing types (modes of representation). Using a case study of the Church of the Three Crosses at Imatra, I present evidence of cognitive loops in key sketches made early in the design process. The essay concludes with a discussion of how such loops facilitate design in the work of many architects, suggesting a direction for collaboration between architects, historians, and cognitive neuroscientists.

Keywords: *Design thinking, concept sketches, Alvar Aalto, action-perception loops, modes of conception, Imatra Church, cognitive neuroscience, exograms.*

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1. Introduction

During the Renaissance painters and architects began to use preparatory drawings such as cartoons and “sinopie” to study their compositions, aided by the ready availability of paper (Ames-Lewis, 1981). Eventually, painter-architects began to use sketches in a similar way, ushering in a practice that has continued for five centuries. During the past fifty years “concept sketches” have taken on a particular importance as evidence of the architect’s individual design predilections (Oechslin, 1982).

Examining these drawings, scholars have explored the connection between preliminary and finished visual works (Gombrich, 1960). In architecture, such sketches have often been used to establish chronologies and early schemes for finished buildings (Wittkower, 1978; Millon & Lampugnani, 1994). Implicit in these studies was the theory that sketches were traces of mental images in the minds of master architects (Hewitt, 1985). The modes of representation used in such sketches, such as perspective

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projections, building sections, and plans, have also been linked to the development of building form (Munshower, 1995; Eisenman, 2003; Van Zanten, 1978).

Among twentieth century architects, Alvar Aalto (1898-1976) was particularly attached to sketching as a means of exploring designs, and hundreds of his preliminary drawings are available for study in the Alvar Aalto Museo near Helsinki (the collection contains 100,000 drawings) (Schildt & Wrede, 1978). Because of this, it is possible to study Aalto's conceptual process in great detail. Recent research on neuroscience and perception also offers new insights into how drawings and cognitive processes interact when visual art is created (Zeki, 1999, 2009). Using this research, it is possible to trace the interaction between images in the brains of architects and the development of designs by studying their sketches (Hewitt, 2008).

2. Ideation and Concept Formation

Neuroscientists have studied the ways in which the brain constructs images, observing that there is a kind of "equivalency" between perceived visual stimuli in the visual cortex and analogous visual concepts (Farah, 1988; Finke, 1980). Pictures in the mind are very like pictures in a drawing, painting, or photograph. It is therefore essential to compare perceptual processes with representational processes when studying how architects design.

Representations such as drawings and models can be useful in a cognitive process such as solving a design problem or composing an art work (Lawson, 1980; Cross, 2011). They are not equivalent to language in written or spoken form. Such representations are also aids to short-term memory. In the cognitive process of design, humans require some sort of external symbol system in order to give the brain a physical adjunct to the image or concept that is internally generated (Arnheim, 1969; Arbib, 2012).

Cognitive science has until recently focused on what is called the Computational Theory of Mind, a theory entirely dependent on language as a symbol system and symbolic logic as an operator. Vinod Goel, at York University, examined art and design cognition using experiments that followed the work of other scientists, but attempted to contest the so-called CTM view. He argues persuasively that designers, confronting physical problems, must employ a wide range of symbolic representations in order to solve cognitive puzzles such as the design of buildings. Moreover, "different symbol systems correlate with different cognitive phases which in turn are associated with different cognitive processes." If an architect is exploring alternative plan diagrams, he will employ plan sketches and draw on examples from his memory of previous plans. It is unlikely that he will engage Broadman's area, which is concerned with language processing, while doing this. He won't need logical operators or subject-predicate pairs in this type of thinking (Goel, 1995; Cohen, 1976).

Goel argues that "sketches" are perfect for the kind of ill-defined, indeterminate cognition that architects use when conceptualizing their buildings. The so-called "problem space" in these instances is open and requires ambiguous or multivalent images. Later, during design development and construction drawing phases, architects are drawn to more conventional linguistic modes of thought, because the information that must be assimilated into designs is often coded in written language or mathematics.

Architects, painters, composers, and poets conceive their works as holistically as possible, despite the potential complexity of seizing the concept for a complete work in

one cognitive flash. The process of conception is not unlike a problem solving process in that steps are involved, but it is difficult to describe these steps in an algorithmic or logical diagram or decision tree. This is one reason why most cognitive science theories do not adequately encompass artistic processes in their diagrams. Most algorithms tend to oversimplify the steps and complex interaction between the designer and the environment, whereas traditional buildings and cities exemplify “organized complexity” in their forms and arrangements. (Salingaros, 2012). There are mathematical models that better describe the design process as “adaptive” so as to allow for the give and take between designers, users and builders (Salingaros, 2018).

Many experiments with architects and designers use common forms of logical and linguistic charts, and often seem quite persuasive in their attempts to capture the design process. In one such study a group of architecture students and science students were asked to solve a three-dimensional puzzle, similar to a Rubik’s cube. The results showed that the two groups had very different approaches to deriving the best solution. The experimenter, Bryan Lawson, concluded that “we might describe the scientists as having a problem-focused strategy and the architects as having a solution-focused strategy” (Lawson, 1980, 42). Among architects the loops used in conceptualization do not readily conform to logical operations, whereas scientists and engineers generally follow linear sequences of reasoning (Goel, 2014; Salingaros, 2018).

Conception, or concept formation, differs from computational cognition in that sensory information becomes an intermediary in the loop between eye, brain, and object (Oxman, 1997). The imagined space of the concept, which can be expressed in external representations, is captured in memory but not fully formed in the mind until realized in its medium (sound, light, paint, physical materials, etc.). An artistic concept thus differs from a purely symbolic one in that a physical form is the desired outcome, but that form cannot be apprehended all at once in the mind’s eye (Shuwairi *et al.*, 2014).

One emerging theory is that visual thinking may be broken into temporal “segments” that are readily definable in all design tasks. These segments can be “forward oriented” or “reflective —backward oriented.” Even this “Creative Segment” theory does not adequately consider the role of habits and internalized modes of thought in most design problems (Sun *et al.* 2014).

Buildings and other occupied spaces are particularly difficult to conceive without sophisticated understanding, through training and experience, of multiple means of representation and physical construction. Cognitive models related to problem solving (algorithmic and logical) do not fully account for the internal and external embodiment of knowledge related to the object that is to be designed and constructed in the physical environment. Precedents must be part of the “discussion” in the designer’s mind (Schon, 1984). Knowledge of the site, place and environment is critical. And social/psychological factors are essential in evaluating how successful a building will be when occupied by a particular user group (Alexander, 2004).

Designers depend upon analogies with existing artifacts in their work, for in the marketplace users are conditioned to the forms of existing buildings, tools, machines, and designed environments of all kinds. Drawing information from these artifacts creates a comparison by analogy in the minds of a designer (Visser, 1996). In addition, architects may use what Charles Sanders Pierce called “abductive reasoning” when working on a design, for “abduction suggests that something may be” in an Aristotelian ontology (Pierce, 1958). Such thinking depends upon references to places, experiences and activities spent with useful artifacts in everyday life. These things often constitute a

pattern of thinking, or of inference, in the minds of trained artists or artisans (Hewitt, 2008).

3. The Action Perception Cycle

When an artist or architect begins a design, they initiate a continuous feedback loop of actions (drawing, sculpting, painting) and perceptions (seeing and judging the artifacts in front of them). Psychologists, neuroscientists, and architects have recognized these cycles of cognition, but until recently there has been limited experimental research documenting their existence. Michael Arbib discusses the most recent findings (Arbib, 2012) noting that the homo species evinced action-perception patterns thousands of years before tool-making, artistic culture, or language emerged in our nearest ancestors. His simple example of an action-perception cycle involves a frog seeing a flying insect, determining its location, and catching the insect with its long tongue. Without both perception (seeing, sensing) and action (motor neurons and muscles controlling the tongue) the frog could not get food. It would seem that drawing what is in one's imagination is a good deal more complex, and perhaps different, from catching an insect.

Almost everything humans do is contingent on the development of skills that involve action-perception loops. Scientists studying perception now recognize that apprehension of the physical world is “enacted” rather than simply sensed; some would say it is “mediated” by the environment (Noe, 2004). What this means is that when a human or other creature surveys and moves about its immediate habitat, it is continuously using perceptions and motor actions to get an adequate reading of what objects are available for manipulation, and which are too far away to be useful. When an object is recognized, a single position or view will not provide a complete understanding of the shape, size, color, or position of the object in the field of sensation (what James Gibson calls the “ambient optic array”) (Gibson, 1966). To get a better “view” of its prey or predator, most animals will move around the organism. Humans tend to do the same thing, but sometimes make assumptions about objects without a full three-dimensional apprehension of their character.

A simple example of this is our general understanding of the roundness of fruits and vegetables. Rounded objects are hard to understand in perspective, as their surfaces appear the same from virtually any angle. Visual perception is sometimes akin to touch in that we “feel” the size, shape and orientation of objects by comparing views from a limited number of positions, and then make a judgment about its probable characteristics. Memories of fruit may help to assess the character of say, a plum, when one has only seen apples and pears previously. Likewise seeing a building section drawing, when one has previously seen only elevations, may help an architect understand both the drawing and the building it depicts.

Writing and research on drawing and model making among architects has generally followed the procedures that designers use in doing studio work, but the cycles of perception and action have not been noted until relatively recently. Sketches and study drawings are the subject of some interesting previous research that will also figure into the discussion below (Oechlin, 1982). It is important to recognize that when a designer makes a preliminary drawing to begin a design, he begins a loop-like cycle of drawing, seeing (the image in mind and the drawing before him), memory retention, discernment, re-drawing, and new perceptions that follow his first attempt (Herbert,

1993). This cycle allows the architect to “survey” the problem before him by physically rendering part of its perceptual content in some external form, such as a drawing or model. In this way he is able to “see” the problem more clearly, thereby understanding what steps to take in order to advance that understanding to the next level.

4. Cognitive Loops and Exograms

As Merlin Donald has theorized, humans developed larger brains with greater internal memory capacity about 150,000 years ago, and began accessing external images about 50,000 years ago. The cave paintings at Chauvet prove that their visual understanding of the environment was quite sophisticated (Onians, 2017). With this development came an ability to employ short and long-term memories in the conceptualization of language, culture, social relations, art, and myths. More importantly, the brain of homo sapiens was primed to use external representations of the world in solving problems, creating objects for use, and understanding the environment. Some of these representations were primarily narrative or linguistic. However, even before written language emerged, humans had the capacity to stimulate creativity with pictures (Donald, 1991).

Pictorial representation is an external device for recording not only the visual field apprehended by the eye and brain, but also abstract concepts about the world, especially spatial concepts (Groh, 2014; Gombrich, 1960). Donald suggests that the limited capacity of biological memory, used for storing language symbols, sensory motor functions, cognitive functions, and the like, did not allow early humans to think theoretically or conceptually.

The development of many kinds of external symbolic forms such as writing and drawing opened up the capacity for conceptual thinking at all levels, using what Daniel Dennett calls “memes” (Dennett, 2017). The brain thus had an adjunct to its internal neuronal storage. The first “loops” of data processing were made possible by these types of representation. The three-step processes are very like the fundamental signal loops that accompany visual perception on a neuronal level (input-processing-output). They are also analogous to computer processes and information theory. The industrial engineer Morris Asimow was among the first to identify such loops during the 1950s. (Asimow, 1962).

Donald’s analysis of the emergence of the modern mind constructs a persuasive argument that virtually all pedagogic, artisanal, theoretical, and even narrative systems are bound together by what he calls the EXMF or External Memory Field, a part of the brain that processes loops between biological memory and external memory. Though speculative, this theory concurs with the observations of many scholars about design schools and methods, from the attributes of Greek sculpture to the functional designs of the Bauhaus. “The EXMF is essentially an external loop for organized thought processes, and there is no substitute for it in biological memory,” Donald argues. (Donald, 1991, 331) See Fig. 1.

One emerging theory that points to the potential “loop” that occurs when architects make a diagrammatic drawing and stare at it, hoping to find a further idea or wrinkle in its vague lines, suggests that the brain anticipates the formation of a new image or idea in the sketch at hand, which is an “affordance” for new thoughts. (Gibson 1986) In such sequences the drawing/image is more than a physical or symbolic representation; it is actually attached to thoughts occurring during conception. The

cognitive “image” and the drawn “exogram” are melded as a concept takes shape. For this reason, it is critical to understand how, and in what sequence, an architect makes his initial drawings, or what I have called his “mode of conception.” (Hewitt 1985) See Fig. 2. With Alvar Aalto, habits formed as early as adolescence influenced these modes of conception.

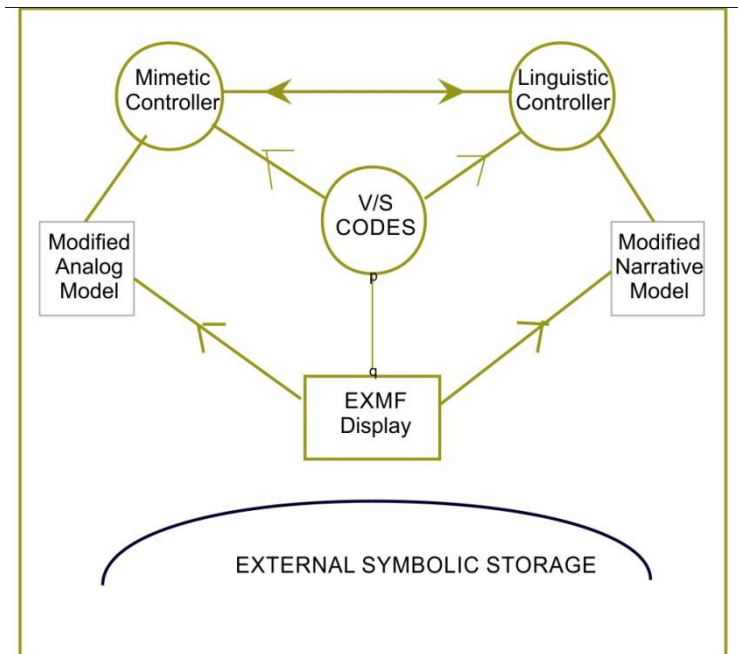


Figure 1. Merlin Donald’s diagram of two systems of external symbolic storage

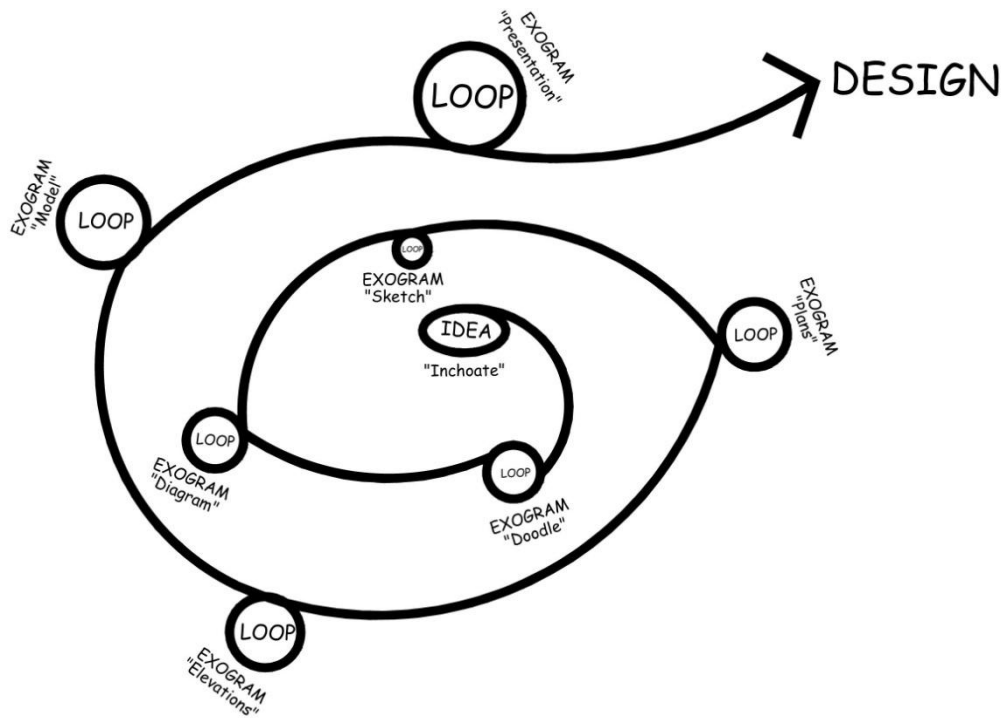


Figure 2. Diagram of the action-perception loops in a typical conceptualization process, a “mode of conception”

5. Aalto's Formative Experiences

The architect's, father J. H. Aalto, was a surveyor who worked for the forest industry. Both Alvar and his brother were present as often as possible to observe his practice. Aalto spoke and wrote vividly in his later years about his hours observing his father at work. In the center of the home office was a huge white table, always abuzz with activity as the staff worked on drawings.

"Maps were drawn on the table of large parts of Finland, and there were problems I wasn't yet able to understand . . . Not all the assistants were always there; sometimes they were out surveying vast forests and unending wilds. Then there was a little space for me, where I could do my own drawing," Aalto wrote to his biographer, Goran Schildt. He created a metaphor that defined his creative process. "I learned—at the age of four I believe—the philosophy of pencil and paper. I can still remember that the hard, sharp, brown pencils were called Eagle. The soft ones were called Koh-i-noor. Besides, there were inks and wash tints next to all the maps around me." He went on to describe the white table as his *tabula rasa*: "It has kept growing. I have done my life's work on it" (Schildt, 1984, 12-13).

Aalto used a similar working arrangement in his own studio. His assistants would gather around him while he sketched at his drafting table. When beginning a project he would collect all the relevant information about the site, client, program, and planning constraints. He would produce, on a role of tracing paper, an extensive "esquisse" (a Beaux Arts term for a rough draft) for a trusted project architect to interpret. The younger architect would then produce scale drawings from the master's small sketches, returning to Aalto when finished. Aalto would then trace over these drawings, adding more ideas to his sketches, and refining his concepts. As the building developed, the master would refine these in sketches, producing a wider "loop" of interaction between his working memory and his exograms (Hewitt, 1989).

Following the concept formation stage, the architect would proceed to develop details of the building using a similar process of refinement in sketches. Aalto thus developed a consistent working method that he employed in all of his mature, post World War II buildings. He had a well-trained staff of both Finnish and foreign architects at his disposal. This cognitive mode can be documented by examining the constructed buildings in comparison to sketches, models and working drawings. One of his most celebrated buildings offers an opportunity to look at the process in some detail. The extant drawings and models at the Alvar Aalto Archives in Jyväskylä show four progressively more sophisticated schemes for this remarkable work.

6. Church of the Three Crosses, Imatra

The Church of the Three Crosses at Vouksenniska, Imatra, 1955-58, is "without a doubt Aalto's most original church design," according to Goran Schildt, his biographer. He began the design in 1954, following his master plan for the "town in the forest" completed in 1953. During mid-nineteen fifties Aalto's office was alive with some of his most important projects, both in Finland and elsewhere in Europe, as both were rebuilding after the destruction of World War II (Schildt, 1984).

Though not himself religious, Aalto was intimately familiar with the role of the Lutheran church in rural communities. He had just completed a large church in Seinäjoki (1951-55), as part of a comprehensive civic center plan for the city. His ideas

about the social function of a parish church were fresh, and he sought to test them in this commission. Like many architects at the time, he believed that new technologies might allow for a multi-functioning building, one that could change its size and configuration according to the needs of the congregation. Aalto made a small sketch of a three-part plan to record his thoughts, initially basing it on several fan-shaped naves from previous designs (Figure 3). In it the wall surfaces are straight lines, or slight curves. Aalto's memory stored this prototype for use in subsequent designs—it was a logical and necessary starting point in the conceptual loop.

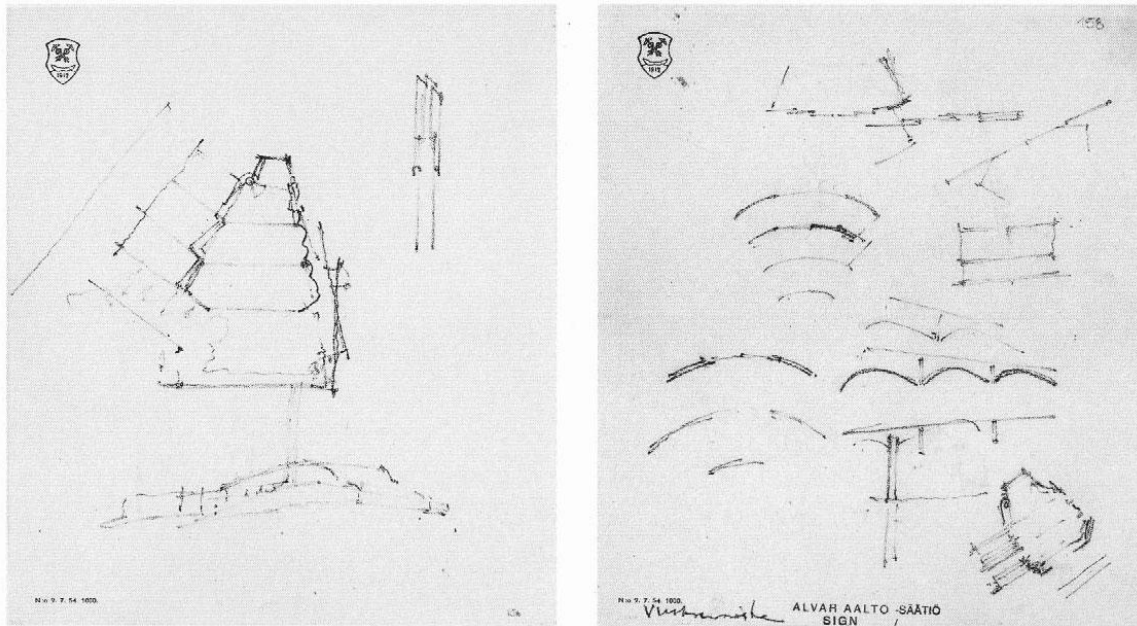


Figure 3, Figure 4. First plan sketches, Aalto Archives, Jyväskylä. Right 20-796, dated July 9, 1954; left 20-797, same date. Listed first and second in the archives

In two subsequent drawings published by Reed (MOMA 1998) the Seinajoki type plan morphs into something very different, based upon a curving section drawing similar to several previous “acoustic” designs such as the lecture room of the Viipuri library. The key sketch shows Aalto making three connected arcs without any reference to either a horizontal or vertical plane. At the bottom right a synthesis appears: a tripartite plan with gently curving outer walls (Figure 4). By combining two previous exograms into a new synthesis, his brain fused images into a new concept.

The crucial synthesis of plan and section concepts occurs in a tiny, single plan sketch (8¼ × 7½ in.): the lower portion of the church, containing vestibules and ancillary rooms, remains rectilinear; but the upper walls facing the forest now balloon outward. The “parti” of the building takes shape after three or four cognitive loops between working memory and sketch memes, Donald’s exograms (Figure 5).

A more extensive esquisse shows his remarkable ability to seize an idea and lay out its salient elements schematically, in plan, section, and elevation (Figure 7). Everything that he needed to visualize is contained in this set of tiny drawings: two floor plans, one more detailed in the middle of the sheet, a small building section, a site plan, and a concept for the tower that would anchor the composition. Moreover, Aalto understood that the position of the pulpit at one side of the fan shaped nave would be an

acoustic source. He drew lines from it in the second plan. These would later be used in a clever model, using light rays to simulate acoustic rays, bouncing off the curved ceiling surfaces of the building (Figure 9). The tracing paper stretched as Aalto made additional exograms to stimulate his inner thoughts. He then made a plan and perspective to envision the three crosses in the nave and project acoustic rays from the pulpit to the three banks of seats in each large volume, now vaulted as if the walls were apsidal, as in an early Christian basilica (Figure 6).

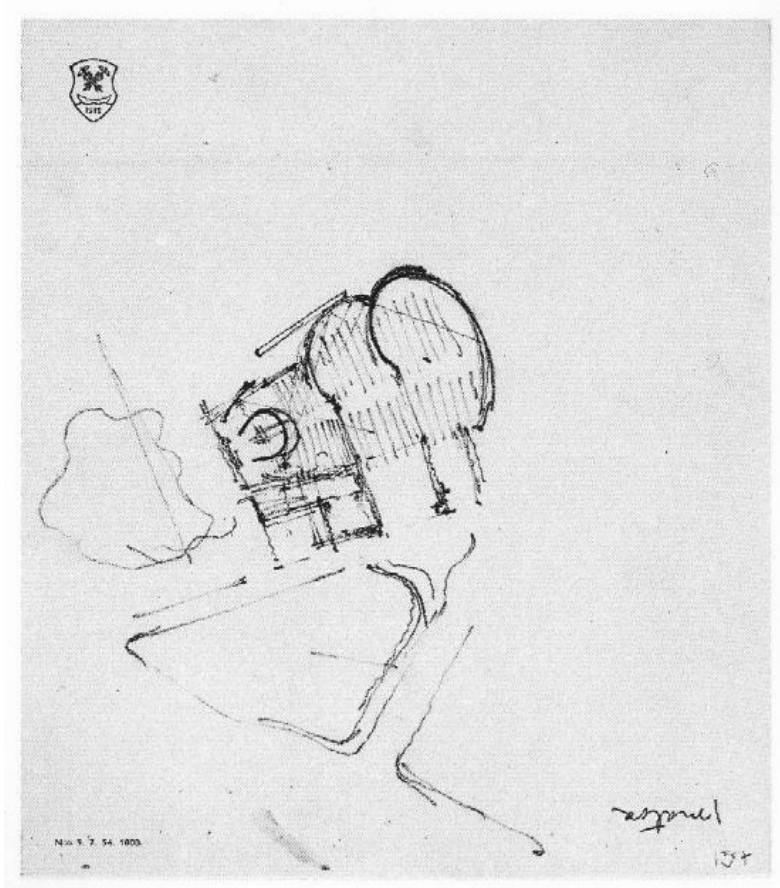


Figure 5. Plan with site plan. AA 20-802

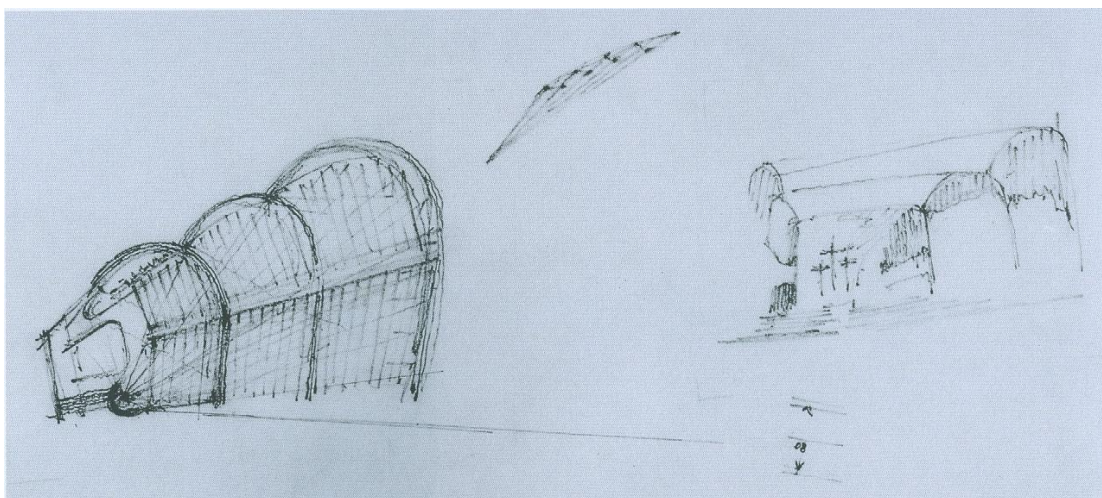


Figure 6. Plan and perspective sketch. AA 20-807A

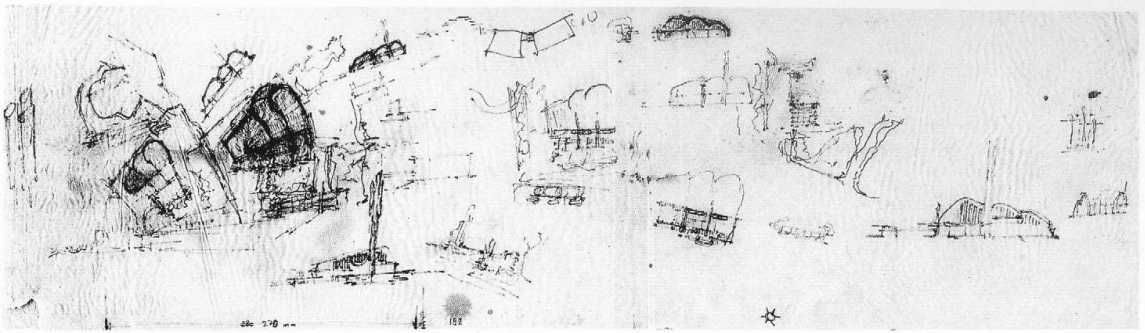


Figure 7. Esquisse drawing of church. AA 20-801

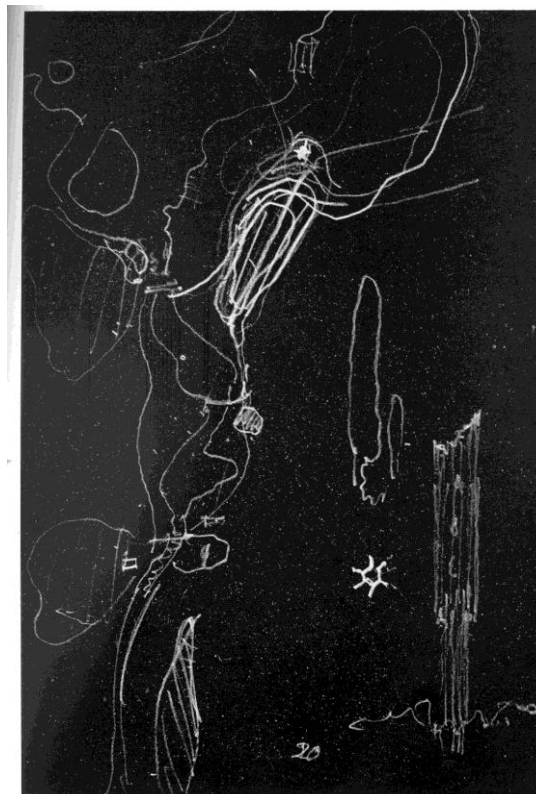


Figure 8. Drawings of tower and site. AA 20-803

Aalto had his draftsmen produce a schematic floor plan, which he then sketched over many times to refine inner wall shapes and outer walls, eventually letting the two find their own forms. The double walled concept allowed him to use a different expressive form for the copper-clad roofs than for the smooth, reflective ceilings inside, and to modulate light entering the nave from above (Figure 10).

Another, scaled plan drawing (Figure 11) shows a further aspect of the architect's working method and imagination: the character of light in the spaces. He first considers a constellation of hanging chandeliers, but chooses not to employ them, as they would clutter the ceiling volumes. A sketch above the plan studies the rib-like dividing walls between the three rooms of the nave, which would contain sliding doors to divide the spaces when necessary.

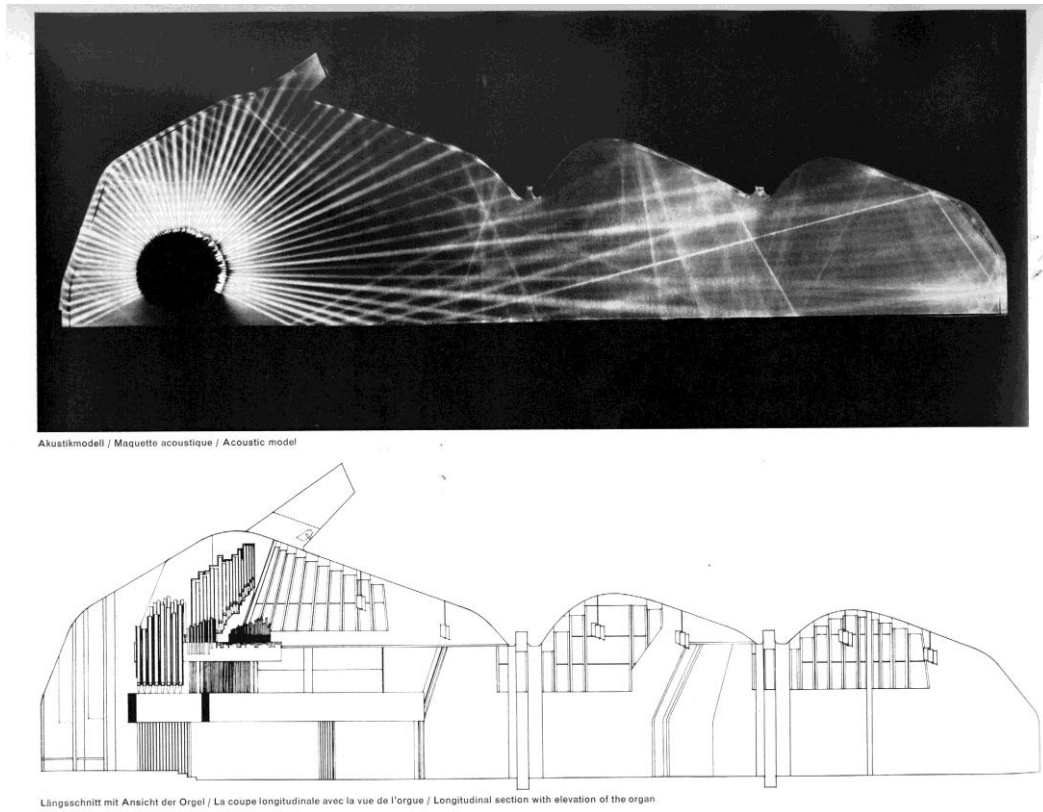


Figure 9, Figure 10. Section and section model

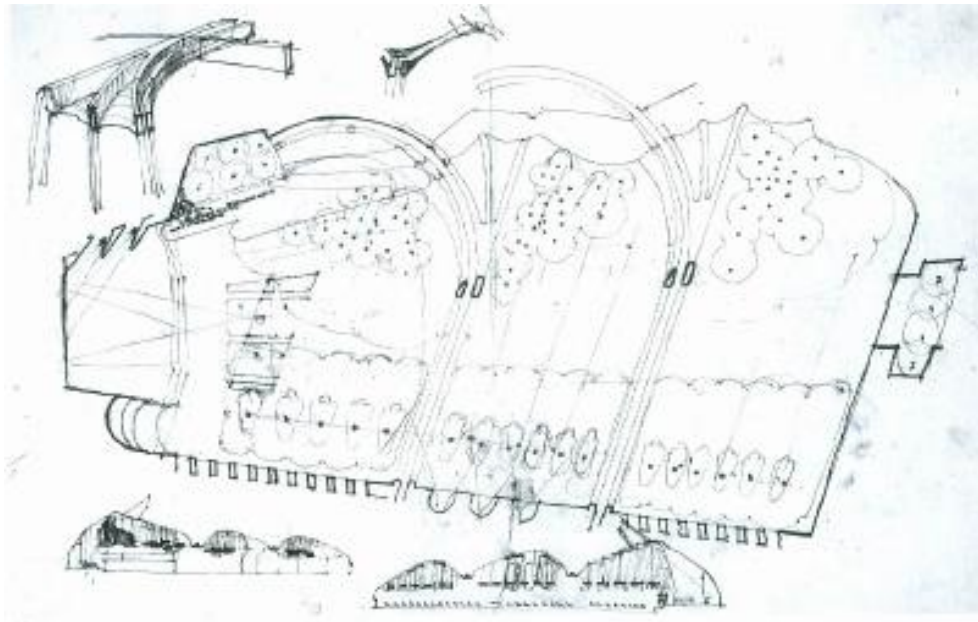


Figure 11. Plan showing lighting locations



Figure 12. Photo of three nave rooms, Aalto Archives, Jyväskylä

A formal site plan allowed Aalto and his assistants to study the relationship of the building to the surrounding wooded landscape. He drew each tall tree in the site to indicate their texture and density, allowing the complexity of his design to reflect that of the natural world. In sketch elevations he consistently related the stepping forms of the roofs to the hillsides, and placed the tower in different positions to maximize its impact on the viewer from all angles. The site plan is very like the contour maps young Aalto had known as a boy, drawn by his father's assistants. A sketch of the tower itself placed its form in memory, comparing it to the forest and the trees of eastern Finland (Figure 8) (Hewitt, 1989).

Remarkably, Aalto's rough sketches eventually became a physical artifact with all the qualities he had in mind (Figure 12,13). Not every architect achieves such a miraculous translation of inner concepts to outer forms. However, most architects trained to use sketches of one sort or another (even sketch models can serve as exograms) will make similar sequences of cognitive loops when studying a design. Since most sketches are discarded, it is often difficult to fully mark the sequential development of a full building or landscape project. The Aalto drawings archive in Finland contains more such preliminary drawings than are available to scholars studying other famous designers, so his work makes an excellent subject for this kind of study.



Figure 13. Exterior view of church, Aalto Archives, Jyväskylä

7. Conclusion

The brain of a young child receives impressions that are beyond rational or cortical reasoning, but which form neural networks of both memories and unconscious patterns of thought. Adding to these recollections, the adult Aalto's educational and mentorship practices, within a distinct cultural milieu and amidst a changing

professional habitus, added formative cognitive patterns to his childhood ideals and paternal admiration.

Like Picasso, Aalto was in touch with both his playful, childhood images and the more sophisticated stimuli acquired as a young adult. As a mature designer he drew on his early memories of contour intervals and maps (Charrington & Nava, 2012). By comparing each site to ones he had experienced he could create "imaginary" landforms and building forms in an integrated composition. His personal mode of conception drew on learned habits of mind such as the production of a tracing paper esquisse, and brought these to bear on each fresh design problem. He could then "forget" the program and budget parameters for a time, drawing only upon unconscious neuronal actions to drive his pencil and thoughts forward (Hewitt, 1989).

Architectural history, as both a documentary and analytical discipline, has not often connected with neuroscience to study problems such as those appearing in this paper (Mallgrave, 2007; Onians, 2017). There are, however, standard models of analysis that trace the sequence of design ideas in well-documented projects, such as St. Peter's Basilica in Rome, Frank Lloyd Wright's Larkin Building, and the planning of Imperial Delhi in India. If these methods are melded with concepts from recent research on the visual cortex, the resulting findings are likely to be significant in both scientific and humanistic scholarly communities.

Among twentieth century architects Aalto was not unique, but his large body of constructed work and comprehensive office archive are unusually broad and deep. Only Le Corbusier and Wright, who maintained extensive office records, are likely to match his output. While publications on these modern "form givers" is already crowded with the analysis of important individual projects, research on their individual cognitive styles or conceptual modes is sparse. If cognitive neuroscience is to contribute to the discourse on architecture, more future research must combine architectural history, design theory, and brain science (Coburn *et al.*, 2017). There is reason to expect a significant paradigm shift in these fields if scholars, designers and scientists combine their tools and expertise in the near future (Alexander, 2004). The results bode well for reform in the design professions, which have labored for years under false or outdated assumptions about the brain, body, and human behavior.

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