Pattern

Context Architecture: Fundamental Concepts Between Art, Science, and Technology

Digitalization has altered the architectural discourse. Today, discussions in architectural theory and design are shaped by many new ideas, including some that previously had no meaning or a very different meaning in that context. Increasingly, the conceptualizations and strategies of architectural discourse are molded by influences emerging along the interface joining scientific and cultural images of modern information technology. Against this background the question arises regarding which practical and, in particular, which theoretical concepts can architecture use as a basis to address these new technologies, while, at the same time, entering a productive and critical dialog with them? *Context Architecture* presents a selection of such ideas, all of which are central to current discourses. *Context Architecture* is a collaboration of the Zurich University of the Arts (ZHdK) and Ludger Hovestadt, chair for Computer Aided Architectural Design at the ETH Zurich.

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Pattern

Ornament, Structure, and Behavior

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EDITORIAL

"It is equally unwise to call a simple pattern an ornament just because it is repetitive. An ornament always has an element of deliberate stylization that elevates a pattern to an independent art form, whereas a pattern remains a form that serves the object. The ornament is always autonomous, even in cases where it merges with the object [...]. Hence it is different to a structure that is merely the object in its *sosein*"[or, essence][1]. Philosopher Hans Heinz Holz dedicates himself with considerable detail to the subject of "ornament" in his collection of art history essays from 1972 titled *Vom Kunstwerk zur Ware* (From art work to product). These essays were at the forefront of a development that would manifest itself in the 1970s in a renewed critical discourse on the meaning and purpose of ornament and the consequences of modern ornament criticism. At the same time, the pattern concept – previously defined chiefly as a structural system of order and a standardizing measure of discipline – began to gain a new complexity and momentum in light of cybernetics and system theory.

Holz must be given credit for clearly differentiating between pattern and ornament, a differentiation that still has value today[2] when we find ourselves once again in a multi-faceted colorful debate, invoking the emotional appeal of new ornament on the one hand and, on the other, offering new, technological possibilities of unknown scope and relevance for design, which are linked to a pattern concept that is becoming more and more dynamic.

Numerous recent publications and the debates that have accompanied them clearly show that ornament is once again very fashionable. This links the critique of ornament with a familiar tradition that had a lasting impact on the entire twentieth century. The verdict of Adolf Loos nearly a century ago ("Ornament is wasted manpower and therefore wasted health"[3]) almost became a phrase of the century, yet it proved neither as traumatic nor radical as hoped by some, and feared by others. At the same time, it is still true that the condemnation of ornament as a "crime" against the logic of the industrial age was not

1 Hans Heinz Holz: "Die Repristination des Ornaments," (The repristination of the ornament) in: *Vom Kunstwerk zur Ware,* Neuwied and Berlin 1972, pp. 140–166, here: pp. 159–160.

2 The relationship Holz drew between ornament, pattern, and structure is particularly relevant here.

3 Adolf Loos: *"Ornament and Crime,"* in: *Spoken into the Void: Collected Essays by Adolf Loos,* transl. Jane O. Newman and John H. Smith, MIT Press, Cambridge 1982, p. 30.

only understandably justified from the perspective of the times, it also became an essential paradigm in how modern architecture defined itself.

In this context, the question of whether ornament criticism is still relevant in architecture, recently raised by the German philosopher Wolfgang Fritz Haug in the title of his eponymous essay *"Ist die Ornamentkritik in der Architektur noch aktuell?"* (Is ornament criticism still relevant in architecture?),[4] refers to the evolution of the ornament debate while simultaneously positing a critical examination of the same. Haug leaves the question unanswered. What is significant however, is his impulse to remain free to re-examine the object of a debate in progress, as well as to focus on the debate itself a point of reflection.

"Digital ornament," "new ornament," "ornament in the digital age" – much is being said and written virtually everywhere about the subject, coupled with high expectations to learn more about the dynamics of current information technologies. What emerges is not only a considerable amount of uncertainty with regard to working with established interpretations of ornament and pattern, but also a need to (re-)invest both with a much needed conceptual clarity. As commendable as the desire to create conceptual clarity may be, the means chosen to achieve this are often limited. Expressed in drastic terms: how is it possible to speak of the global dimensions of a "digital age," and the associated deep structural changes, and at the same time hope to study and understand the architecture designed and produced with the tools of this very age, either by means of an established ornament concept, or by working with a broadening of concepts, which are nonetheless limited to the degree of *newness* or to digital methods?

For this reason, it is futile to again pose the question: What is pattern? What are patterns? For our context, two interpretations of this fundamental question take shape at the outset. First: the concept of pattern can no longer be discussed as a subcategory of ornament. In fact, the opposite is true. Ornament is derived from the concepts of pattern and pattern formation. Second: The concept of pattern, in its function as a computer science-based broadening of the "design pattern" developed by Christopher Alexander, provides a pro-

4 Wolfgang Fritz Haug: "Ist die Ornamentkritik in der Architektur noch aktuell? (Is ornament criticism still relevant in arcitecture?)," in: *Entwurfsmuster. Raster, Typus, Pattern, Script, Algorithmus, Ornament* (Design pattern, grid, type, pattern, script, algorithms, ornament), in: *Arch+,* No. 189, October 2008, pp. 109–111.

mising starting point for the reflection on architecture that is increasingly produced on the basis of digital and generative systems. Yet when discussing the pattern concept that was greatly influenced by Alexander in the 1960s, and the resulting concept of *pattern* as adapted and radicalized by computer science, we must not lose sight of the question of sense and meaning, which is so essential to architecture. In other words, we are dealing with the question of the extent to which patterns can be derived from computer science, not only for the purpose of solving complex problems on the level of software, but also with the goal of generating architectural meaning. These questions create discursive prospects in the discussion about "ornament in the digital age," which make it unavoidable for architectural theory to risk peeking over the conceptual borders of previously established realms of discourses. The conceptual outlines of these prospects are still unclear and sketchy.

Consequently, this third volume in the *Context Architecture* series intends to explore the above-mentioned discursive prospects, to sketch out their contours, and to emphasize the architecture-related, potential main points of a debate now taking shape in the era of information technology. Oscillating between abstraction and reflection, the pattern concept plays a crucial role in many different disciplines. Yet this is not about defining new conceptual borders, but rather about delineating and opening up a future scope for discourse. Beyond the computer science and architecture dialog that is relevant in this context, we have also attempted to prioritize disciplines such as cognitive science, which are particularly suited to a dialog on architecture.

Christoph Hölscher describes how this dialog might look in his essay. The simple question, "How do we find our way through built space?" not only makes clear how spatial behavioral patterns can be identified experimentally, but also how these empirically conveyed results can be integrated into architectural planning with the help of multi-agent systems.

The transition from cognitive science to neuroscience is frequently hasty and lacking in sufficient critical reflection. In the process, one often forgets the abstraction and fine complexity of the microcosm in the field of neuroscience. For this reason any attempt to find a correlation between neurological patterns in the brain, regardless of how they are defined, and the seemingly related architectural impressions cannot be an expected element in serious discussions of architecture theory or cultural philosophy.

Nevertheless, we decided to include a contribution on neurobiological patterns. This was not an attempt to somehow validate architectural design, in light of the continued craze for measurability displayed by the on-going fascination with neuroscientific research methods and findings. We invited neuroscientist *Markus Christen* to write an essay, because we were interested in a differentiated approach to the concept of pattern and its multifaceted complexity.

We have not only included the natural sciences, but also an artistic discipline that has always been closely associated with architecture: music. From the composer's artistic perspective, we can read about observations made by *Isabel Mundry* concerning her own as well as other contemporary compositions in relation to pattern formation in contemporary music. She examines the question "Why Patterns" in dialog with the title of a composition by Morton Feldman. The composer draws a connection to architecture by linking the issue of pattern largely with the parameter of *time,* which is an architectural factor in music.

When Christopher Alexander began working on his now, revolutionary *Pattern Language* at the end of the 1960s, the views he presented were seen as formalistic and exotic. This changed, as we know, when the term that he coined, *design pattern,* was adopted approximately a decade later by computer science – in which context it became the concept of design patterns but, in architecture, was by then considered outdated and irrelevant. Today, thirty nearly forty years after the publication of *Pattern Language,* Alexander's design pattern appears to have returned to architecture, its original domain, after a successful stopover in computer science – albeit on a completely different level. *Fabian Scheurer* traces the path of this return through examples of current projects, and he investigates whether developments in computer science are helpful in developing new ideas for the process of designing and constructing architecture. The fact that in this context he is discussing the picture of an "architect designing with algorithms" demonstrates that his question also addresses the impulse to critically (re)examine the concept of design and, hence, its associated architectural identity.

The historical context of Alexander's *Pattern Language* reveals that Alexander attempted as early as the 1960s to dedicate himself to a similar idea. It is rarely mentioned in discussions about his design patterns, but worth noting that Alexander was one of the first architects to write his own computer programs for the purpose of architecture. He did this at a time when the computer was still considered a tool of the future, and when his cultural notions oscillated between a picture made by a drawing machine and fantasies of an electronic brain. New light is shed on aspects of the current ornament and pattern discussions when considering, as *Georg Vrachliotis* does in his essay, not only design pattern and its history, but also Alexander's early investigations of the computer's role in architecture.

The current approach to the proclamation of a "new" ornament is the starting point in *Andrea Gleiniger's* contribution. Derived from the context of architecture history, her essay deals with the issue of how the current debate responds to the past vicissitudes of a discussion that had a lasting impact on the twentieth century. It also addresses the question of the cultural foundations upon which a new understanding of ornament can be based. Because if this is true in light of the Loos-inspired dictum formulated by Adorno – which states that "criticism against ornament (...) is like criticism against that which has been lost by its functions and symbolic meaning"[5] – then the opposite should also be true: ornament can only claim validity if it has regained not only a functional, but also a content-related context of justification, or in other words, symbolic meaning. This need for symbolic meaning creates a kind of "crisis of interpretaion" (a need to fill a void), but, at the same time, also offers new scope for interpretation. In light of the quantity of written material regarding the ornament that was socially critical and, thus, in line with experiences of the twentieth century, it is almost impossible to avoid looking for these social references. And this perhaps all the more so, as Robert Venturi and Denise Scott-Brown always stated: the critique they wrote in response to the everyday and to pop culture was – in light of the irony inherent in their methods – an essentially serious strategy, whereby they were never only interested in mere decoration, but also always in cultural references.

5 Theodor W. Adorno: *Funktionalismus heute* (Functionalism today), lecture at the conference at the Deutschen Werkbundes, Berlin, October 23rd, 1965; published in: *Neue Rundschau,* 77. volume, 4. edition, 1966. Quoted after: Theodor W. Adorno, *Gesammelte Schriften,* published by Rolf Tiedemann with the collaboration of Gretel Adorno, Susan Buck-Morss, and Klaus Schultz, Vol. 10.1, Kulturkritik und Gesellschaft I, Frankfurt (1977) 2003, pp. 375–395, p. 376.

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We are grateful for the opportunity to continue this productive cooperation, which presents the potentiality of a dialog between architecture, art, science, and technology and discusses the transdisciplinary aspirations of two institutions with the upcoming fourth volume in the *Context Architecture* series on the concept of "code."

Andrea Gleiniger & Georg Vrachliotis

Andrea Gleiniger

NEW PATTERNS? OLD PATTERNS? – ON THE EMOTIONAL APPEAL OF ORNAMENT

The notion of pattern formation took production and life conditions by storm at the beginning of the twentieth century, and raised fundamental questions regarding the ornament. Later, around the middle of the century, the autonomy of pattern concepts intensified the call for ornament as a meaningful metaphor. Consequently, architectural criticism[1] that was inspired not least by critical theory no longer primarily focused on a social reality in which everything, previously expressed by ornament, had lost its "symbolic and functional meaning"[2] because mechanical or industrial production methods superseded the traditional relationship between skilled work and ornament. On the contrary: ornament, which was so effectively "ousted" by the paradigm of modern design in the abstraction of material and color, structure, "textur und faktur,"[3] now epitomizes precisely the loss of meaning diagnosed in light of postwar aberrations in architecture and urban planning. This means that the same developments which vehemently rejected *ornament* in favor of a rational pattern theory essentially aligned themselves with the technocratic strategies of simplification and standardization introduced by industrial (architectural) production, and defined *pattern* foremost as standard, type, and norm. This pattern theory became the basis of all the ideas about serialization, which comprised not only the systemization and rationalization of production processes, but also analyses of human behavior.

On the one hand, the "Modernist project" was challenged in a variety of ways, whereas at the end of the era of cybernetics the grand, primarily urban planning visions of architectural system theoreticians – which supposedly

1 See Heide Berndt, Alfred Lorenzer, Klaus Horn: *Architektur als Ideologie* (Architecture as ideology), Frankfurt (1968) 1979.

2 "symbolischen und funktionalen Sinn," Theodor W. Adorno: *Funktionalismus heute* (Functionalism today), lecture at the conference of the Deutsche Werkbund, Berlin, October 1965; published in: *Neue Rundschau,* Vol. 77, 4th edition, 1966. Quoted after: Theodor W. Adorno, *Gesammelte Schriften,* published by Rolf Tiedemann with the collaboration of Gretel Adorno, Susan Buck-Morss, and Klaus Schultz, volume 10.1, Kulturkritik und Gesellschaft I, Frankfurt (1977) 2003, pp. 375–395, p. 376.

3 Compare with László Moholy-Nagy: *von material zu architektur* (From material to architecture), published by Hans M. Wingler. Facsimile of the 1929 edition, Mainz 1968, p. 33 ff.

forced the complexity of life and functional contexts into monotone and monocultural patterns – were heavily criticized.

Ornament as an aesthetic, sensorially perceivable *notion of possibility* fell victim to pattern's *sense of reality.* It took refuge in idealizations of geometrization that were now being sharply criticized "as a relapse into ontological consciousness,"[4] while, at the same time in the tranquil configuration of a "lived space," the "Ornament der Masse" (Ornament of the masses) (1927), as formally described by Siegfried Kracauer, attempted to arrange itself into an "open society" (Karl Popper) within the new neighborly experimental design.

The discourse on the function of ornament – a thematic focus inherent in architecture – circumvented the question of symbolic and substantive qualities of meaning beyond genuine architectural self-reflection. At least for as long as the responses provided by semiotics and, ultimately, postmodernism to the challenges raised by the ornament question, secured new scope and spurred critical, ironic, and playful positions.

Thus the pattern theory as a rational phenomenon, and the ornament theory as a sensorial and meaningful phenomenon, were mutually exclusive. Yet this seems to be changing with possibilities made available by modern digitalization: the patterns have started moving and ornament is experiencing a renaissance. Now ornament is being postulated as a type of emerging phenomenon, as an excess of algorithmic pattern production, which accrues from its apparently infinite number of notions of possibility. As an aesthetic reshaping of the generative, pattern-based design process and its tectonic results, it is named in the sense of the "enrichment" that Christian Norberg-Schulz described in the logic of a structuralist functionalist skepticism as early as the mid-1960s.[5] Yet, an ornament theory thus derived from the spirit of geometry, can integrate – albeit under the new design technological auspices of non-linear geometries – fairly seamlessly into the continuity of the largely ontological idealization of processes inherent to architecture, which had become the

4 "als Rückfall in ein ontologisches Bewusstsein," Alfred Lorenzer: "Städtebau: Funktionalismus und Sozialmontage? Zur sozialpsychologischen Funktion der Architektur" (Urban planning: functionalism and social motage? On the social psychological function of architecture), in: see note 1, p. 53/54.

5 Christian Norberg-Schulz: "Architekturornament," in: *Ornament ohne Ornament?* (Ornament without ornament?), publ. by Mark Buchmann, exhibition catalog in 5 brochures, Zurich (no. 5) 1965, pp. 24–29.

mark of Modernism and its respective attempts at transcendence. And this, exactly where one had hoped for a *"Zuwachs an Sein"*[6] (or a growth in essence) that would point beyond the algorithmic conditions of a *Gemachtsein* (or, the produced or made). But if we want to take the question regarding ornament seriously, we need to discuss it in context of its significance regarding function, tectonics, and design technology, as well as its sustained or renewed significance, its "symbolic meaning" (Adorno).

"Patterns for glass, patterns for plasterwork, patterns for ash trays, patterns for fixtures, patterns for paint, everything is waiting for a decision…" In this solemn itemization from 1948, Swiss architect and writer Max Frisch bemoans the tedium involved in an architect's daily decisions, despite all the rigor of architectural, day-to-day cautious satisfaction.[7] Frisch, however, also reviews the elements of the external appearance of architecture as material examples. His "patterns for…" thus creates an exemplary basis for decisions about the future design of a place, which moreover is related to certain aesthetic expectations. The elements are also something far more prosaic: they are *product patterns.* Ernst H. Gombrich refers to the *product patterns* facets of meaning in his preface to *The Sense of Order.* "It also became a jargon term for a type of precedent and has therefore lost any precise connotation it may have once had."[8] He leaves it as a reference to the "oscillating usage" of the jargon applied in relation to ornament and pattern (in different languages). He is not so much interested in their semantic oscillation, but rather in the "headstrong attempt"[9] to empirically comprise and explain the changing pattern of

6 For example, Jörg Gleiter referring to Hans Georg Gadamer in: Jörg H. Gleiter: "Zur Genealogie des neuen Ornaments im digitalen Zeitalter. Eine Annäherung" (On the genealogy of the new ornament in the digital age. An approach), in: *Entwurfsmuster. Raster, Typus, Pattern, Script, Algorithmus, Ornament* (Design patterns. Grids, types, pattern, script, algorithmics, ornament), *Arch+,* No. 189, October 2008 pp. 78–83, here: p. 82.

7 "Muster für Glas, Muster für Verputz, Muster für Aschenbecher, Muster für Beschläge, Muster für Lasur, alles wartet auf Entscheidung…", Max Frisch: *Tagebuch* (Diary) *1946–1949,* Frankfurt am Main 1950 (1971), p. 313. Frisch's statement relates to the Freibad Letzigrund in Zurich, completed in 1949, which was Frisch's first and last large architectural commission.

8 "The Sense of Order. A Study in the Psychology of Decorative Art," Wrightsman Lectures, Vol. 9, Oxford, 1979, p. X. The German quote reads: "… das Wort *Muster* […] längst nicht mehr gleichbedeutend mit *Ornament* empfunden [wird]." Ernst H. Gombrich: *Ornament und Kunst. Schmuckbetrieb und Ordnungssinn in der Psychologie des dekorativen Schaffens,* Stuttgart 1982, p. 10.

9 See: Willibald Sauerländer: *In Memoriam Sir Ernst Gombrich 30.3.1909–3.11. 2001,* The Gombrich Archive. www.gombrich.co.uk/obituaries.php.

ornaments in the approach to design theory inspired by Wolfgang Köhler and J.J. Gibson, and the epistemologically inspired manner of Karl Popper. Gombrich was interested primarily in the fundamentals of art pertaining to psychology and theories of perception.

It is worth remembering that Gombrich's large-scale, sophisticated study, which had long become a standard work, was created against the backdrop of a personal biography that witnessed the emerging definition of the discourse on ornament, a fundamental preoccupation in architectural history throughout the twentieth century. Gombrich was born in 1909 in Vienna at the onset of Modernism. Eloquently described by Theodor W. Adorno, Gombrich's contemporary and his senior by only six years, in his lecture *Funktionalismus heute* (Functionalism today) at a symposium of the Deutsche Werkbund in 1965, it was a time when "Schönberg's compositional innovations, Karl Kraus' literary battle against the newspaper phrase, and Loos' denunciation of the ornament [...] do not correspond in some vague analogy relative to the history of ideas, but [are] rather directly the same *Sinnes*."[10] Yet in contrast with Adorno – and others who programmatically processed the polemic, sparkling provocations of Loos' critical essays during the functionalism criticism that emerged throughout the late 1950s, and the accompanying re-emergence of the ornament discourse – these were neither a core point nor explicitly the occasion behind Gombrich's own investigations.[11] Notwithstanding, Gombrich, who diagnosed Loos' "radical attitude" as a "symptom of the unease" at the turn of the century, chose the derided house on Michaelerplatz (1909ff.) in Vienna, known at the time as the "house without eyebrows," to use as a prime example of the resistance that can be met by such innovation for conservative sentiments and traditional habits of perception.[12] Even though Gombrich's choice of subject is difficult to read without pre-knowledge of the "denunciation" of the ornament by protagonists of classic modernism, the art historian – who had already reflected innovatively in *Art and Illusion* about the fundamental concepts of perception theories – was now interested, in the context of cognitive

10 "die kompositorischen Neuerungen Schönbergs, der literarische Kampf von Karl Kraus gegen die Zeitungsphrase und die Denunziation des Ornaments durch Loos [...] keineswegs in vager geistesgeschichtlicher Analogie [stehen], sondern unmittelbar desselben Sinnes [sind]," see note 2, p. 377.
11 See note 8, pp. 59ff.
12 Ibid., p. 180.

and art theoretical logic, in the anthropological connotations of the origin of ornament in the guise of the "ornamental industry and concept of order." By referring to perception and Gestalt psychology, he emphasizes not only the "psychological dimension"[13] and the approach to his investigations from the perspective of perception theories; he also elevates the meaning of the ornament to a kind of archetypical basic condition of the human need to express, to an anthropological constant. With his own emphasized reference to the cognitive theoretical methods of Karl Popper, he also enters the context of a scientific theoretical process that claims a procedural dynamic of "trial and error" as its basic principle, and, at the same time, acquires its productive cognitive energy from the conflicting relationship between "schema and correction."[14]

Perhaps this complex art theory approach, which extends beyond the contained realm of the largely architecture-related ornament discourse, is the reason why Gombrich, in today's increasing number of publications dedicated to pattern and ornament, is only ever mentioned in footnotes, as a respectful, polite reference. And, then, usually for a propagandist effect, as background music for product aesthetics, and not as a serious critical reflection on the subject. At the same time, this lesser role may be due to the fact that the ornament discourse was established in the context of functionalism criticism, which is rooted in architecture and the relevant disciplines associated therewith. On the other hand, the influence of *critical theory* gave rise to an architectural criticism that castigates the ontological consciousness of all those who look for cultural and social redemption in the pure spirit of mathematics, respective of geometry.[15] Gombrich thought this was due to ornament theory being based on and having correlations to perception and Gestalt psychology. Today's ideas focus more on a psychological dimension largely anchored in the social realm and the community.

13 "Schmuckbetriebs und Ordnungssinns," "psychologische Dimension," see Klaus Lepsky: *Ernst H. Gombrich, Theorie und Methode* (Theory and method), with a preface by Ernst H. Gombrich, Vienna, Cologne 1991, p. 86.
14 See here the introductory chapter "Order and Purpose in Nature," see note 8, pp. 13ff., and note 13, pp. 37ff.
15 See note 4.

Ornament and Abstraction

The vacuum created by the programmatic abstinence from ornament in (classic) modernism was filled by the call for a pure geometry of form and "material appearance."[16] In postwar architecture, this "banishment of the ornament" to the "absolute inoffensiveness" and abstract ambiguity of modern decoration experienced a "tragicomical" continuation.[17] Criticism was also directed at the "geometric correctness" of the ornamental "pattern," facades by one Egon Eiermann that utterly completed "the banishment of the ornament from today's architectural practice."[18] More than that, they also paved the way for an architectural branding aimed at "the arrangers of the consumer world"[19] and, hence, emphasized a development the relevance of which cannot be underestimated, particularly in regard to the growing omnipresence of decorative *pattern.* The *product pattern* is disappearing behind the pattern as product.

Ornament and Nature

Analogous to constructivist and functionalist rationalizations in architecture and design, there is a new focus directed at organic growth and nature's "biotechnical"[20] "construction role models."[21] For the most part, this re-examination of nature occurred in the new media and through visualizing technologies, in particular photography[22] and microscopy.

16 "Materialerscheinungen," see note 3, p. 31, and caption for figure 21.
17 "Verdrängung des Ornaments," "absoluten Unanstössigkeit," "tragikkomische," see note 4, p. 53.
18 "geometrische Korrektheit," "die Verdrängung des Ornaments in der Praxis der heutigen Architektur weitgehend vollendet[en]," Michael Müller: *Die Verdrängung des Ornaments. Zum Verhältnis von Architektur und Lebenspraxis* (The repression of the ornament. On the relationship between architecture and life), Frankfurt 1977, p. 12.
19 "den Arrangeuren der Konsumwelt," Wolfgang Pehnt: "Sechs Gründe, Eiermanns Werk zu lieben. Und einer, es nicht zu tun" (Six reasons to love Eiermann's work, and one reason not to) in: *Egon Eiermann 1904–1970. Die Kontinuität der Moderne* (Egon Eiermann 1904–1970. The Continuity of Modernism), exhibition catalog Karlsruhe, Berlin, published by Annemarie Jaeggi, Ostfildern-Ruit 2004, pp. 17–29, here pp. 23ff.
20 "biotechnische," László Moholy-Nagy specifically refers here to Raoul Francé and his biotechnics theory. See note 3, p. 60.
21 "Konstruktionsvorbilder," ibid.
22 Of particular consequence in this context is Karl Blossfeld: *Urformen der Kunst* (The basic forms in art), Berlin 1928 and ibid.: *Wundergarten der Natur* (The magic garden of nature), Berlin 1932.

Suddenly it was no longer about a mere copy in the sense of "a purely ornamental exploitation of natural forms,"[23] but rather about a structural identification or recognition related to the design and construction of nature's visual appearance. The "discovery of the microscopic fine structure of matter" and its "microphotographic" visual rendering, as documented in Moholy-Nagy's visual investigations,[24] not only visually renders "natural forms derived from inorganic material," it also allows them to "appear thoroughly ornamental to the aesthetic consciousness."[25]

"The projection of plant life in technical forms"[26] became a paradigm of Modernism with Louis Sullivan's celebrated ornament studies and the explicit relationship he established between function and form. However, this is no longer purely about the floral and plant-inspired ornamentation of Jugendstil, which was criticized as two-dimensional and hence as superficial. It is far more relevant as the impetus for formulating an analogy that developed out of the study of organic (and inorganic) nature and that has had serious implications for the (self-) validation of architecture, even for the biotechnical adaptations of today. This analogy between nature as the given and architecture as the formed is extended from its cultural and metaphorical context to an existential, structural context.

Ornament and Structure

In the gravitational field of the structuralist-influenced discussion about the current state and the future of modern architecture and design in the 1960s, the structure paradigm also becomes a basis for ornament's new self-validation. The cultural context (as determined by western society) is influ-

23 "einer nur ornamentalen Ausbeutung der Naturformen," see note 3, p. 60 and pp. 70ff.

24 "Entdeckung der mikroskopischen Feinstruktur der Materie," "mikrofotografische," see note 3, p. 35.

25 "einer nur ornamentalen Ausbeutung der Naturformen," "ästhetischen Bewusstsein als durchaus ornamental erscheinen," Hans Heinz Holz, "Die Repristination des Ornaments," (The repristination of the ornament), in: ibid.: *Vom Kunstwerk zur Ware. Studien zur Funktion des ästhetischen Gegenstandes* (From the artwork to product. Studies on the function of the aesthetic object), Neuwied, Berlin 1972, pp. 140–166.

26 "Die Projektion pflanzlichen Lebens in technische Formen" "…folgt dem Ritual des Banns" (…follows the ritual of the ban), Gert Mattenklott in Karl Blossfeldt: *Alphabet der Pflanzen* (The alphabet of plants), publ. by Ann and Jürgen Wilde and text by Gert Mattenklott, Munich 2007, p. 9.

enced by *abstraction;* the discussion regarding the ornamental character of any type of structure becomes a point of focus, in that it deals with the simple repossession of decorative qualities and their value. It is, moreover, essential to produce a meaningful relationship[27] between the artistic, cultural majority and a social reality that increasingly bemoans the loss of symbols.

The exhibition *Ornament ohne Ornament?* (Ornament without ornament?), which was a topic of discussion in 1965 at the former Zürcher Kunstgewerbemuseum (now the Museum für Gestaltung), became a crucial event in this context.[28] It documented the attempt to trace the phenomenon of the ornament in diverse disguises, substitutions, and transformations triggered by Modernism. The tendency for materials popular in Modernism to sprawl in every possible thematic direction produced a very inspiring, yet also "confusing," phenomenology of ornamental visual appearances. These in turn became a thematic focus compliant with experiences based on the psychology of perception. However, this had much to do with visual customs and cultural influence, and very little to do with an attempt to fundamentally establish a contemporary ornament theory.

The exhibition gave philosopher Hans Heinz Holz occasion to write a review, but it also inspired him to methodically examine the conditions and properties of the ornament.[29] Obviously, neither Holz nor Max Bill,[30] were able to gain much from the exhibition: "Buchmann [the curator of the exhibition, author's note] sees ornament everywhere. [...] One actually wonders if the exhibition directors may have thought, in all the pre-exhibition excitement, that they may not have found all that many examples of the ornament at all, or if they actually fell victim to seeing ornament in almost anything. [...] There are some ornament-free forms that, when piled together, might seem ornamental to

27 See here Gombrich, note 8, p. 73/74, as well as Holz, note 25, pp. 164ff.

28 See note 5.

29 The chapter quoted in note 25 refers to his review "Ornament ohne Ornament," in: *Basler National-Zeitung*, August 15, 1965, and his resulting essay in the exhibition catalog *Ornamentale Tendenzen in der zeitgenössischen Malerei* (Ornamental tendencies in contemporary painting), Berlin, Leverkusen, Wolfsburg 1968.

30 Max Bill: "Sinn ohne Sinn?" (Sense without sense?), in: *Zürcher Woche,* No. 29, July 16, 1965, p. 13: Bill mentioned in his review that no differentiation had been established between the different terms that mark the semantic field of gravitation in the ornament discourse: "Ornament, decoration, pattern, structure, grid, rapport [...]."

people who bring the appropriate visual custom along with them to the exhibition."[31] Holz then began to methodically examine – some years before Gombrich – the "categorical problem" and the "conceptual diffusion" of the ornament theory. His definitive methods are largely the product of an art-history and aesthetics-theory objectification.[32] They present the practical differences between pattern and ornament,[33] and define its formal terms.[34]

However, one voice can be heard above the theoretical and the visual panopticon of the Zürcher exhibition catalog. It carries a weight in terms of architectural history that is difficult to overestimate at any point in time. In just a few pages, Norwegian art historian Christian Norberg-Schulz jotted down the outline of a theory of "architectural ornament" that is actually recognizable as an adaption of a structuralist thought process (as well as its ontological transcendence) on the question of ornament.[35] However, unlike other authors, Norberg-Schulz argued strictly within the framework of architectural trends and "design function." He attempted on a formal basis to reclaim the ornament theory that was a form of "enrichment" for historical architecture, and that had the expressed function, above all, "[...] to clarify and emphasize structure." The ornament is "of crucial significance for formal articulation."[36] Referring to Louis Sullivan[37] and his hopes for the cathartic effect brought on by an era of radical abstinence from ornament, Norberg-Schulz infers: "We apparently experienced the period where one abstained from using ornament only to

31 "Ornamentales findet Buchmann allenthalben. [...] Tatsächlich fragt man sich, ob im Eifer der Planung die Ausstellungsleiter nicht allzu viel ornamentales entdeckt zu haben glauben, ob sie nicht dem Fehler verfallen sind, in fast jeder Form schon ein Ornament zu sehen. [...] bestimmte ornamentfreie Formen, die in additiver Häufung auftreten, [sind] ornamental erlebbar für den, der eine entsprechende Sehgewohnheit mitbringt," see note 25, p. 248/249.

32 Ibid., here mainly: pp. 163/64

33 Ibid., here p. 147 or pp. 159ff.

34 These formal terms then served as the starting point for Michael Müller in his quoted studies on the ornament, see note 18.

35 See note 5.

36 "[...] die Struktur zu klären und zu betonen," "von entscheidender Bedeutung für die formale Artikulation," see note 5, p. 26.

37 Ibid., p. 24

tackle the problem of enrichment again. But whether this takes place in a way that can be characterized as 'safe' it is a different issue."[38]

Ornament as *"Zuwachs an Sein"?*

Propagating "a revival of the ornament according to 'past examples'"[39] seems just as untenable today as it did in light of the loss of meaning and symbols diagnosed in functionalism criticism – an approach that was more or less successfully undercut by postmodern narrative strategies. What Michael Müller established in 1977 in relation to Heide Berndt seems far more applicable: namely "an architecture that aspires to develop an 'aesthetically innovative and psychologically, highly differentiated formal language,' in other words, also a type of ornament, to account for the technical state of its available materials," and thus to "measure the future design of architecture [...] against the current availability of technological developments and possibilities."[40] So far so good. And that is precisely what the apologists of "new ornament"[41] seem to have provided with their basis of legitimacy. The new emotional appeal of the ornament is the emotional appeal of the technological archive of instruments in design and material!

Design strategies based on information technology have created a genuine surplus that is related, in regards design, to the production conditions of architecture. Moreover, this was achieved in the symbols of industrial production or a *mass customization* that challenged the compulsion to systemize industrial production! Consequently it is now possible to achieve the opposite of what the norm and the standard-oriented Tayloresque struggles with type, norm, and standard had always refused – despite a certain amount of diversity

38 "Wir haben heute augenscheinlich die Periode durchgelebt, da man von der Verwendung des Ornaments abstehen möchte, um jetzt wieder das Problem der *Bereicherung* anzupacken. Es ist aber eine andere Frage, ob dieses in einer Weise geschieht, die man mit den Worten ‹ohne Gefahr› charakterisieren kann." ibid.

39 "eine Wiederbelebung des Ornaments nach 'vergangenen Vorbildern'," see note 18, p. 17.

40 "demgegenüber [...] eine Architektur, die eine 'ästhetisch neue und psychisch hochdifferenzierte Formensprache entwickeln will', also auch eine Art von Ornament, den technischen Stand der ihr zur Verfügung stehenden Materialien zu berücksichtigen» habe, und damit «die künftige Gestalt der Architektur [...] an dem jeweiligen Stand der technologischen Entwicklungen und Möglichkeiten zu messen sei," ibid., p. 8.

41 For example Jörg Gleiter, see note 6.

that developed over time. The technological notions of possibilities, however, are initially self-referential. The patterns on which this is based are technically rational; the emergence created by their interaction is a technical rationale to which broader, more general meaning cannot be attributed by implication. Yet it is precisely this meaning that should be the primary issue, if one desires to distance oneself from the packaging aesthetics of the decorative production of patterns that are more or less original and that moreover *disguise* – in a familiar manner – rather than *clothe* – in the now somewhat outmoded manner of Semper. In addition, by mimicking Anglicism they avoid the question of meaning which has always been associated with ornament.

The concept that has congealed into the term pattern, in the sense of decorative pattern, falls far behind the concept of ornament, while the pattern theory, gained from the generative dynamic of the design pattern, seems to be extending beyond itself and projecting the "new ornament," which is being discussed so ardently again.

The desire for form is also a desire for meaning. Norberg-Schulz spoke of enrichment, and he meant something similar to the ontologically effective added value in the structuralist operation.

Yet what is the meaning today? Where is the *"Zuwachs an Sein,"* of which Hans Georg Gadamer spoke, he who did not hesitate to question the fundamental principles of aesthetics – that is, beauty – or even the relevance of this issue during the shift from the industrial age to the information age?[42]

We should be occupied with this question. And it does occupy us, at least when we encounter the question: "What remains of architecture when programmatic efficiency [...] threatens, in this manner, to take the upper hand? What happens to the political and social ideals that spurred Modernism as a project? Will they become ghosts in the haunted house of architecture"[43] and never rest, while we, the offspring, are mistreated for so long that we not only listen to them but also start finding new answers? Instead of a (clear) answer,

42 Hans-Georg Gadamer: *Die Aktualität des Schönen. Kunst als Spiel, Symbol und Fest* (The relevance of the beautiful. Art as game, symbol, and celebration), Stuttgart (1977) 2006.

43 "Was bleibt von der Architektur, wenn die programmatische Effizienz auf diesem Wege [...] überhand zu nehmen droht? Was passiert mit den politischen und gesellschaftlichen Idealen, mit denen die Moderne als Projekt gestartet war? Werden sie als Geister im Spukhaus der Architektur," Nikolaus Kuhnert: Editorial, see note 6, p. 9.

for which it is most likely too early, Kuhnert quotes Antoine Picon, who continues with the same issue in the same edition of *Arch+,* of whether we should be wary of the absence of political, social, even communal utopias.[44] Yes, it should make us wary, or in other words, it should sensitize us to what is going on in the "haunted house of architecture,"[45] wherein the ghosts of Modernism (and their critical descendants, who always considered the project of Modernism as incomplete anyway[46]) are rumbling that they have "not had their last say: although their power may fade in light of the development of computer-aided design, they are not whispering to anyone who will listen about old stories of projects that could have been at once aesthetic, political, and social."[47] They remind us that design and its ingredients, such as ornament, are still responsible for the "ornamental industry and sense of order," as well as a complex series of psychological needs that are deduced in a variety of ways. And maybe this is a chance: the globalized and "globalizable" pattern of information-technology design strategies will not be able to achieve this as long as it restricts itself to extravagance in product aesthetics and post-post-functionalist technology enthusiasm. The chance lies in the ability for productive surplus to transform into an identity that is related to the relevant cultural context and points beyond architecture-inherent terms.

We now face the task of contextually relating architecture to its associated questions regarding design and form and perhaps even regarding beauty and ornament, in order to produce socially and culturally relevant meaning.

44 Antoine Picon: "Das Projekt. Von der Poesie der Kunst des Entwerfens" (The project: on the poetry of art design), in: see note 6, pp. 12–17, here: p. 12.

45 "Spukhaus der Architektur," ibid., p. 17.

46 Jürgen Habermas: *Die Moderne – ein unvollendetes Projekt* (Modernism – an incomplete project). Acceptance speech for the Adorno Prize 1980. In: *Die Moderne – Ein unvollendetes Projekt. Philosophisch-politische Aufsätze* (Modernism – an incomplete project. Philosophical political essays), Leipzig 1990.

47 "ihr letztes Wort noch nicht gesprochen: Obgleich ihre Macht angesichts der Entwicklung des computergestützten Entwurfs zu schwinden droht, flüstern sie nicht nur all denjenigen, die ihnen zuhören wollen, alte Geschichten von Projekten ins Ohr, die auf eine untrennbare Weise zugleich ästhetisch, politisch und sozial sein könnten," see note 45.

Georg Vrachliotis

"AND IT WAS OUT OF THAT THAT I BEGAN DREAMING ABOUT PATTERNS..."[1]

ON THINKING IN STRUCTURES, DESIGNING WITH PATTERNS, AND THE DESIRE FOR BEAUTY AND MEANING IN ARCHITECTURE

"In a computer, you can of course set a number of parameters and churn out endless combinations and variations, but if they don't have meaning they are really just trivial games,"[2] explains the architect and mathematician Christopher Alexander to his two attentive listeners, architect Rem Koolhaas and curator and writer Hans Ulrich Obrist. They had asked Alexander's opinion on the trend in contemporary architecture to regard the computer primarily as a machine for generating an "endless number of varied and individual shapes."[3] "For the people that live in a world that is created like that, it is actually frightening. It's not joyful, because it isn't coming from anything actual," responded Alexander. "You can read the insincerity of it. It's trying to fake variation, but it's the wrong kind of variation. If you look at a plant and see the amount of variety within an inch, you may learn a lesson about architecture."[4]

Yet, what did Alexander really mean when he spoke of computer-generated processes in contemporary architecture resulting in a "fake variation"? And how does all this relate to what is being discussed under the still somewhat awkward label of "digital neostructuralism"[5] in the contemporary discourse on pattern, ornament, architecture, and information technology?

The discussion between Alexander, Koolhaas, and Obrist took place in October 2007 in Alexander's home in England. The discussions focused once again on the colossal work Alexander had published over a decade earlier,

1 "Von fliessenden Systematik und generativen Prozessen. Christopher Alexander im Gespräch mit Rem Koolhaas und Hans Ulrich Obrist" (Of flowing systematics and generative processes. Christopher Alexander in discussion with Rem Koolhaas and Hans Ulrich Obrist), in: *Entwurfsmuster. Raster, Typus, Pattern, Script, Algorithmus, Ornament,* in: *Arch+,* No. 189, October 2008, p. 25 (This and all the following quotes derived from this discussion are taken from the unpublished English transcript, translated by Kristina Herresthal, printed in: ibid, pp. 20–25). Appreciation goes to Nikolaus Kuhnert and Anh-Linh Ngo for the original citations.

2 Ibid.

3 Ibid. p. 24.

4 Ibid. p. 25.

5 Nikolaus Kuhnert and Anh-Linh Ngo: "Editorial," in: ibid, p. 8.

A Pattern Language.[6] They were still – or perhaps it is more appropriate to say once again – occupied with this work of over 1000 pages, which is the most popular and debatable[7] result of a project that continued for almost ten years at the *Center for Environmental Structures* at the University of California, Berkeley. Alexander not only addressed the underlying ideas of his design pattern and the concept of nature it contained during the discussion, but also current trends in digital architectural production. Given the current search for a "culture-form" as a complement to the "structure-form" of the computer,[8] the first impression seems to be that architecture and architectural theory are now succumbing to the temptation of blindly following current trends regarding *patterns, structures,* and *ornaments.* Because of innovative technological production methods, the adjective "digital" is often placed before these above-mentioned terms in order to impart a sense of the modern and the new by means of an added prefix. The reason ornament is discussed more often than pattern, even though the latter is often the main concern, is the fact that pattern theory is far more abstract and, hence, more difficult to discuss. On the other hand, constructing arguments and precedents for the contemporary debate on architecture using the countless historical discourses involving ornament theory is extremely tempting, as it might conceivably pave the way for new potential meaning. In this context, re-examining Alexander's *A Pattern Language* is a chance to productively traverse the dense thicket of countless pattern theories that are often discussed solely in terms of their affinity with ornament.

It is fascinating to note that accounts of Alexander's design patterns rarely mention that he was one of the first architects to write his own computer programs for the purpose of solving design problems at the beginning of the

6 Christopher Alexander, Sara Ishikawa, Murray Silverstein with Max Jacobson, Ingrid Fiksfahl-King, Shlomo Angel: *A Pattern Language. Towns, Buildings, Construction,* Cambridge 1977.

7 Alexander used the term "pattern" even before it made history in the context of the "Pattern Language." See, for example, Christopher Alexander: "The Pattern of Streets," in: *Journal of the AIP,* Vol. 32, No. 5, September 1966, pp. 273–278. For a critical voice from this time, see Christoph Feldtkeller and Dietrich Keil: "Alle mal pattern! Oder Zur Idiotiekritik. Anmerkungen zu Christopher Alexanders 'Major Changes in Environmental Form Required by Social and Psychological Demands'," (Suddenly pattern! Or on the idiocy critique. Notes on Christopher Alexander's 'Major Changes in Environmental Form Required by Social and Psychological Demands'), in: *Arch+,* No. 8, October 1969, pp. 29–35.

8 Same as footnote 5, with a reference to the system theoretician Dirk Baecker, p. 7.

1960s – at a time when the computer was still considered a tool of the future as regards architecture, and when its cultural image still oscillated between drawing machine and fantasies of an electronic brain. If we consider not only the design patterns and the history of their origins, but also Alexander's early research into the role of the computer in architecture, we see certain aspects of the current discourse on ornament and pattern in a different light. The reflections that follow are therefore an attempt to explore and discuss the contours of these aspects.

Christopher Alexander and the Computer

At one of the first international conferences on the relationship between architecture and computers, the *First Boston Conference on Architecture and the Computer* (1964), which included architect Serge Chermayeff[9] among the speakers, a then thirty-year-old Christopher Alexander confidently announced his ideas on the core aspects of designing with the computer. Whereas the development of innovative graphic tools was the primary focus of the then rapidly-expanding field of computer graphics,[10] Alexander was an early and vehement critic of this widely popular area. At the Boston conference, held the same year Alexander's highly respected doctoral thesis *Notes on the Synthesis of Form*[11] was published, Alexander was able to introduce his ideas to a wider public for the first time [Fig. 1]. He immediately presented them an entire series of counter-arguments to popular questions and basic hypotheses that frequently arose in relation to architecture, design, and the computer. He polemically confronted the proponents of computer-aided design present at the conference – one of whom happened to be the computer pioneer Steve Coons – with his alternative views on architecture and the computer. In stark contrast to their prevalent philosophy, which defined the computer in architecture largely as an intelligent drawing machine, Alexander represented the viewpoint of a structure-oriented, experimental design culture whose primary focus was neither on forms of representation, nor a subsequent digitalization of finished design concepts:

9 See Serge Chermayeff and Christopher Alexander: *Community and Privacy: Toward a New Architecture of Humanism,* New York 1963.

10 See William A. Vetter: *Computer Graphics in Communication,* New York 1964.

11 Christopher Alexander: *Notes on the Synthesis of Form,* Cambridge 1964.

Fig. 1: Christopher Alexander working on his book *Notes on the Synthesis of Form.*

"In my opinion the question [...] 'How can the computer be applied to architectural design?' is misguided, dangerous, and foolish," is how Alexander began his speech to the astonished participants of the conference. "We do not spend time writing letters to one another and talking about the question 'How can the slide rule be applied to architectural design?' We do not wander about houses, hammer and saw in hand, wondering where we can apply them. In short, adults use tools to solve problems that they cannot solve without help. Only a child, to whom the world of tools is more exciting than the world in which those tools can be applied, wanders about wondering how to make use of his tools."[12] To Alexander, the true strength of the computer was found in its extraordinary ability to calculate. A computer was nothing more to him than "a huge army of clerks, equipped with rule books, pencil and paper, all stupid and entirely without initiative, but able to follow exactly millions of precisely defined operations."[13] He was vehemently opposed to the popular tendency to ascribe artificial intelligence to computers. In response to the argument, fashionable at the time among developers of computer-aided design, that computers were able to swiftly generate a massive diversity of ground plans or façade variations from every conceivable perspective, Alexander declared soberly, "At the moment, the computer can, in effect, show us only alternatives which we have already thought of. This is not a limitation in the computer. It is a limitation in our own ability to conceive, abstractly, large domains of significant alternatives."[14]

Alexander's grasp and incisive theoretical insight into the newly emerging field of research into the potentials and limitations of the computer with regard to architecture was truly remarkable, even at this early stage. His response to any computer critics was challenging and defiant: "Those that fear the computer itself, are invariably those who regard design as an opportunity for personal expression. The computer is a threat to these people because it

12 Alexander, Christopher: "A Much Asked Question about Computers and Design," in: *Architecture and the Computer. Proceedings of the First Boston Architectural Center Conference,* Boston, December 5, 1964, from the archive of the Department of Architecture, MIT, 1964, p. 52. See also "The Question of Computers in Design," in: *Landscape,* Vol. 14, No. 3, 1965, pp. 6–8.
13 Ibid.
14 Ibid, p. 53.

draws attention to the fact that most current intuitive design is nothing but an outpouring of personal secrets in elastic form."[15] However one may wish to evaluate Alexander's later views on the role of the computer as an architectural design instrument, at that time his ideas were revolutionary, albeit markedly more sober and humble than the technological fantasies of Coons or Joseph Carl Robnett Licklider.[16] In the closing words of his lecture, he made a statement that confirmed why he – compared to the many other leading figures at the conference – was considered a serious participant who should also be taken seriously as a contributor to the architectural debate.[17] "[...] There is really very little that a computer can do, if we do not first enlarge our conceptual understanding of form and function,"[18] Alexander stated, leaving no doubt by making this reference to the architectural concept of function and form just how much his understanding of architecture and technology differed from the majority of the debate on visually-oriented computer graphics at the beginning of the 1960s. Hence, in Alexander's opinion, the computer's true application potential as regards architecture was largely at a structural level. In this manner, he reversed the directional vector in the relationship between architecture and technology: the social logic of an architectural design and the associated idea of diversity should not be adapted to suit the technological logic of the computer and its ability to produce countless variations; it should rather occur the other way round. If we recall, in this context, the discourse between Alexander, Koolhaas, and Obrist quoted at the beginning of this essay, and Alexander's criticism of the trivial game of variations, it is clear that his basic theories about the computer remained largely unchanged for over forty years.

15 Ibid, p. 55.

16 American psychologist Joseph C. R. Licklider was considered a core figure in early computer research. The popular idea of being able to turn a computer into an interactive drawing machine is largely attributed to him.

17 See for example the rather heated podium discussion between Alexander and Peter Eisenman, on November 17, 1982 at the Harvard School of Design. Printed under the title, "Contrasting Concepts of Harmony in Architecture," in: *Lotus International,* No. 40, 1983, pp. 60–68 [thanks to Vera Bühlmann for this reference].

18 Christopher Alexander: "A Much Asked Question about Computers and Design," in: *Architecture and the Computer. Proceedings of the First Boston Architectural Center Conference,* (from the archive of the Department of Architecture, MIT, Boston, December 5, 1964), 1964, p. 55.

On Design Patterns

"I'm terribly sorry but the only way I can do this project is to have the people do it..."[19] wrote a young Alexander at the end of the 1950s to the government of the federal state of Gujarat in India. They had approached Alexander about a planning and construction scheme for an entire village, which promised to be a project of considerable volume. It is at first puzzling why he rejected an assignment that would have been very lucrative for any architect. Yet Alexander's dissatisfaction made him stick by the ideal of developing better, participatory planning models, and, in the above case, he actually placed his theoretical ideas above the laurels of architectural practice. Alexander had made a previous unsuccessful attempt in the same Indian village to fulfill the idealistic goal of having the locals rather than architects create the design on site. The designs were to be based on easily understood design diagrams.[20] "What happened, very simply, is that I thought and thought about it... And it was out of that that I began dreaming about patterns, because patterns are a more explicit instrument for the use of a person."[21] Regardless of whether the term used is *diagram* or *pattern,* understanding Alexander's overall philosophy depends upon understanding that he was always interested in programming ways of approaching a problem: from "the anthropological source to the actual thing, the building form, and the neighborhood form"[22] [Fig. 2]. There is an assumption of the existence of cultural archetypes that, in Alexander's approach, become the components of a collection of a densely intertwined, complex system of rules as anthropological constants in the form of formal instruction: "There was a general feeling in the 1960s that both society and the environment mirror each other, and that if one starts to take the structure of the environment seriously enough one inevitably becomes involved in reconstructing society. This is not a particular social philosophy, just a recognition that by 'patterns' one means behavioural patterns as well as spatial patterns [...]"[23] Based on this fundamental structural attitude and driven by a personal conviction and a desire to under-

19 Christopher Alexander: as note 1, p. 22.

20 See Kari Jormakka (ed.): *Diagramme, Algorithmen, Typen,* in: *UmBau,* No. 19, Vienna 2002.

21 Christopher Alexander: same as footnote 1, p. 22.

22 Ibid.

23 Stephen Grabow: *Christopher Alexander. The Search for a New Paradigm in Architecture,* Boston 1983, p. 55.

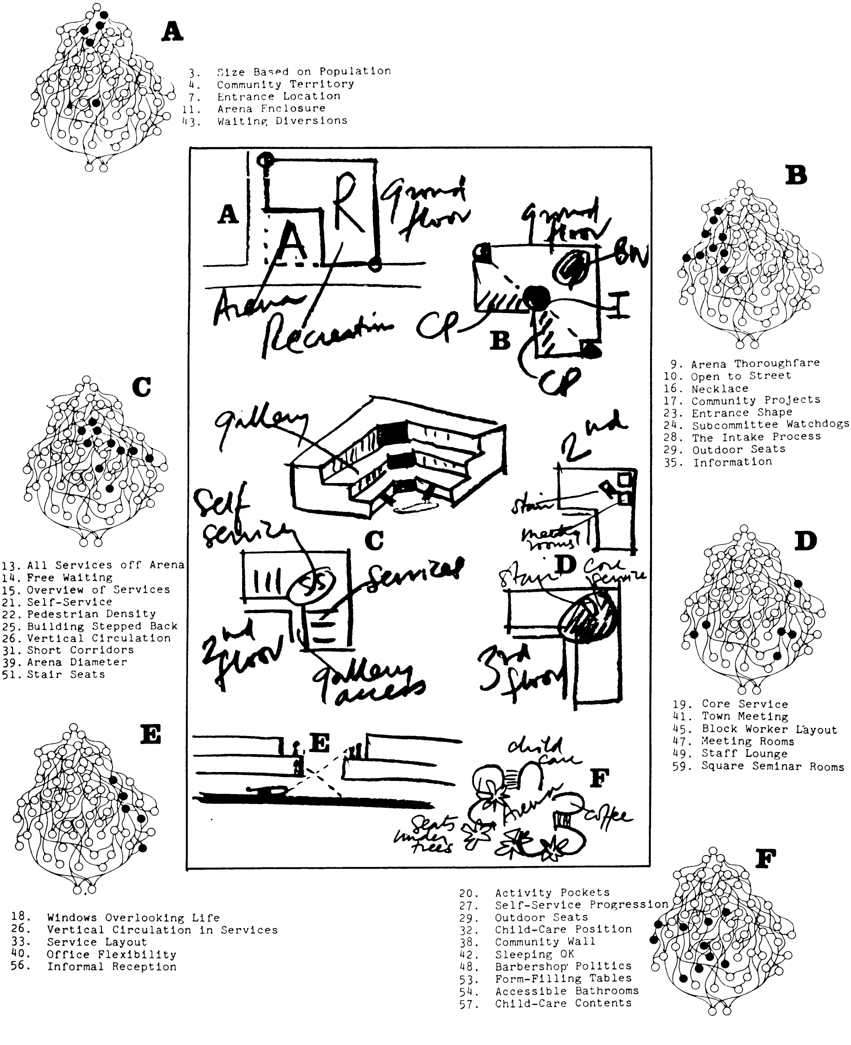


Fig. 2: Christopher Alexander, diagram of the individual design phases for the Multi-Service Community Center in San Francisco with corresponding Pattern.

stand "how form came about from society,"[24] Alexander began to research the world around him from the perspective of generative systems.[25] It is a world of relations in which the architect's task is restricted to identifying, researching, and allowing some of these relations to become explicit. Each object can thus be defined through a network of relations, whereby each spatial situation can be described as a topological environment of structures, a construct which Alexander calls "relational complexes in architecture"[26] [Fig. 3].

In *Design ist Unsichtbar*[27] (Design is invisible), the title of which is an interesting play on Marshall McLuhan's "Environments are Invisible,"[28] Lucius Burckhardt, the urban economist and planner, offers very likely the clearest description: "One can understand the world as a world of objects that can be divided into houses, streets, traffic lights, newspaper stands, and so on. This division way has consequences; it leads to the idea of design as demarcating a specific item (or object). [...] But we can also divide up the world in a different way, and if I have understood the *Pattern Language* correctly, I think this is precisely what Christopher Alexander attempted to do. He did not draw his line between houses, streets, and newspaper stands, in order to build better houses, streets, and newspaper stands. Instead, he divides the integrated complex *street corner* from other urban complexes: after all, the newspaper stand thrives when my bus doesn't arrive, thus giving me time to buy a newspaper, and the bus stops exactly here because various paths and commuters have direct access to connecting routes. 'Street corner" is but the visual description of the phenomenon; it also contains components of organizational systems: bus routes,

24 Same as footnote 1, p. 21; see also Christopher Alexander: "From a Set of Forces to a Form," in: *The Man Made Object.* Vision and Value Series, Vol. 4, New York 1966, pp. 96–107.

25 Alexander's ideas about generative systems were influenced by *Team X,* but more so by the American linguist Noam Chomsky, whose works, in Alexander's words, were at that time "a revelation." (Same as footnote 1, p. 24). See here Noam Chomsky: *Syntactic Structures,* The Hague 1957.

26 Christopher Alexander, Van Maren King, Sara Ishakawa, Michael Baker, Patrick Hyslop: "Relational Complexes in Architecture," in: *Architectural Record,* September 1966, pp. 185–189.

27 Lucius Burckhardt: "Design ist unsichtbar," in: *Design ist unsichtbar,* publ. by Helmuth Gsöllintner, Angela Hareiter, Laurids Ortner, Vienna 1981, pp. 13–21. See also Christopher Alexander: "Kunst und Design für das 21. Jahrhundert" (Art and design for the 21st century), in: ibid. pp. 101–115.

28 "Environments are invisible. Their ground rules, pervasive structures, and overall patterns elude easy perception." Marshall McLuhan: *The Medium is the Massage. An Inventory of Effects,* New York 1967, p. 68.

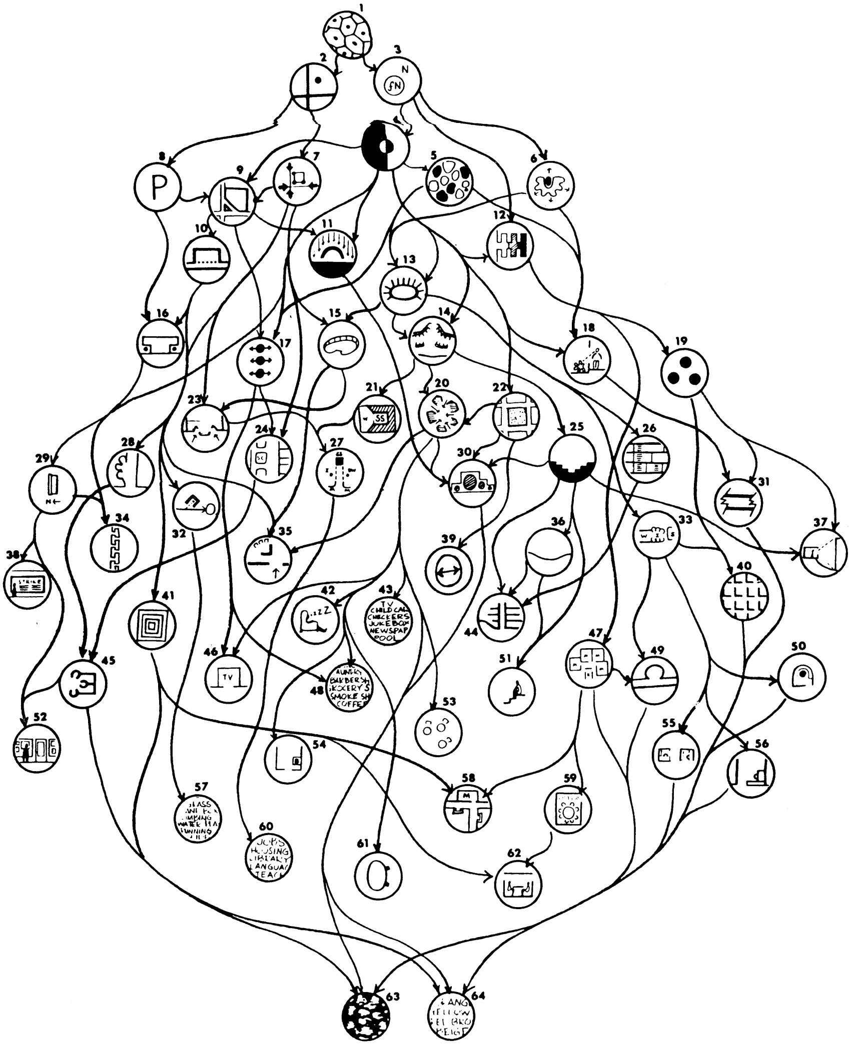


Fig. 3: Christopher Alexander, grid of the 64 Pattern for the Multi-Service Community Center in San Francisco.

timetables, newspaper sales, and so on. This division of the environment also provides an impulse for design. Yet – in contrast to the previous approach – this one incorporates the invisible components of the system."[29]

In his description, Burckhardt emphasizes what may well be the most essential condition for understanding a concept of meaning or beauty that is based on design patterns, regardless of how one might otherwise define it in theoretical terms: the *being-interwoven-with-the-context.* In other words, "structural contextualization" as a design principle that generates meaning. Ultimately, this is exactly the objective of the synthetic aspects in Alexander's *Pattern Language* and is what turns the term *pattern* into "design pattern."

"I am trying to make a building which is like a smile on a person's face [...],"[30] is how Alexander once, albeit rather cryptically, explained his main objective, thereby employing an almost transcendental metaphor to better illustrate his belief in how vital it was, in the process of synthesizing, to *visualize* a concealed, metaphysical structure [Fig. 4]. "For me, the beauty of a thing is not in how it looks. It has to do with how it is."[31] The fact that a certain amount of dogmatism is ascribed to Alexander – in all his attempts to come closer to this platonic notion, by means of formalizing a generative system of rules, and to a participatory model of thought based on diversity – should not take away from the fact that he was already considering an alternative to the Cartesian aesthetic of modernist architecture.

Why the Pattern Theory is Currently Mightier than any *New Ornament*

The answer is quite straightforward: not only is Alexander's pattern theory celebrating a comeback in architecture at the geometric level of parametric models,[32] there also seems to be a veritable quest for a "new ornament"[33] – whether at the level of computer-generated architectural structures or in the interest of

29 Ibid. p. 15.

30 See footnote 23, p. 21.

31 Ibid, p. 56. The impulse to (once again) reflect on beauty in this context is due to a recent discussion with Sokratis Georgiadis, for which I thank him sincerely.

32 See Fabian Scheurer's essay in this book, p. 41–55.

33 See Francesca Ferguson: "Ornament neu aufgelegt," in: *Ornament neu aufgelegt/Resampling Ornament,* exhibition catalog of the Schweizer Architekturmuseum (SAM), Basel 2008.

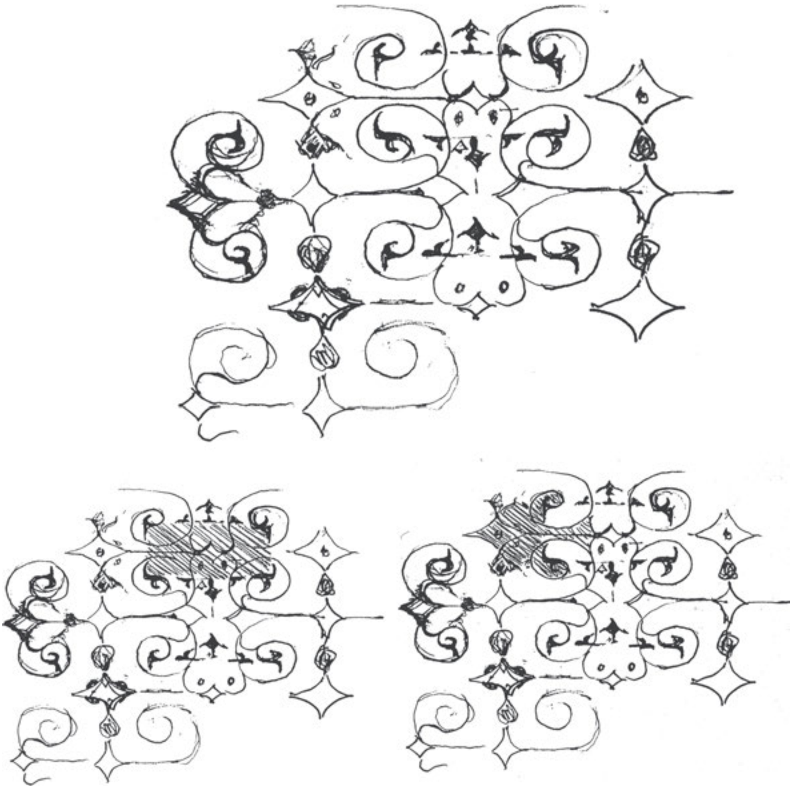


Fig. 4: Christopher Alexander demonstrated the idea of a comprehensive pattern language using the fine and complex patterns of antique carpets: "As a main part of my work, I have found it necessary to go deeper and deeper into the actual making of buildings. Not just the obvious structural part, but the fine-tuned fabric of which the building is made up. Its members, floors, roofs, wall patterns, floor details – in sum, the way the building is made at the microscopic level. [...] In short, the small structure, the detailed organization of matter – controls the macroscopic level at a way that architects have hardly dreamt of. [...] Thus the idea that when we make the world, we are trying to produce this endless structure, in which tiny organization of color and form produces the structure of the world – is literally and physically embodied in a carpet." Christopher Alexander: *A Foreshadowing of 21st Century Art. The Color and Geometry of Very Early Turkish Carpets,* New York, Oxford 1993, p. 7ff.

a broader reflection on the theory of ornament and the related history. The ornament discussion ignites the question of whether every digitally created, "computer-generated, repetitive-geometric element" has in fact always been the anticipated "new ornament in the digital age,"[34] or whether it is actually more often *only* pattern and structures. In this context, pattern theory is thus invariably trotted out whenever the question of meaning is raised in connection with a differentiation by comparison to ornament. Although an ornament is always also a pattern in terms of structure, it does not necessarily follow that a pattern is always an ornament.

Thus the *pattern* theory, as it is frequently discussed against this background, occupies an implicitly weaker position in cultural history than the *ornament* theory. For this reason, the first hypothesis states that the current discourses on the *new ornament* or the *digital ornament* may well be sophisticated academic treatises. However, their internal structure debunks any notion of sophistication, revealing them instead as rigid debates that are only partially capable of achieving a theoretical grasp of the dynamics of the "fundamental structural change in architecture"[35] that is indeed taking place today. In his comprehensive work on the "new ornament in the digital age," architectural theoretician Jörg H. Gleiter refers to Gottfried Semper's *Über Baustile* (On architectural style) and the latter's conclusion "that architecture's initial conditions, its development, its production, and realization, is all manifest in the ornament."[36] However, this is ultimately an attempt to expand the ornament theory by placing it at the constructive level and linking it to digital production technology. This linkage is no doubt correct. One aspect of modern architectural production, which is being discussed more and more frequently, will in fact be the increasing dominance of computer-generated construction and production methods: pure design processes are no longer separated from pure production processes, a shift that Gleiter refers to as the "interactive connection between design and construction methods" in an allusion to architectural

34 Jörg H. Gleiter: "Zur Genealogie des neuen Ornaments im digitalen Zeitalter. Eine Annäherung," (On the genealogy of the new ornament in the digital age. An approach), in: same as footnote 1, p. 78. See also: ibid.: "Kritische Theorie des Ornaments" (Critical theory of the ornament), in: ibid.: *Architekturtheorie heute,* in the series: ArchitekturDenken, Vol. 1, Bielefeld 2008, pp. 75–93.

35 See Gleiter: "Zur Genealogie des neuen Ornaments im digitalen Zeitalter," in: see footnote 1, p. 78.

36 See footnote 35, p. 80.

historian Mario Carpo. If the "algorithmic logic of digital technologies"[37] is understood as the essential building block in the search for a definition of the *new ornament,* then the formal space in which architecture resides is identified as that of a "symbolic machine"[38] without, however, making any statement as to whether this also necessitates an expansion of architectural questions.

Therefore, another hypothesis is directly linked to the first, and it refers to the now precarious, theoretical view of computer-generated architecture. By specifying and ultimately defining an historical, however justified, *digital ornament,* one hopes to "interpret architecture that seemed initially puzzling and difficult to clearly assess."[39] Consequently, the second hypothesis is a direct repudiation of the field of interpretation anticipated here. Rather, given the global operating range of information technologies, the second hypothesis argues that the theory of the *new ornament* is no more capable of achieving the desired expansion of interpretation than it is capable of delivering the somewhat perplexing desire for a "unambiguous assessment" of architecture.

In other words, how is it possible to speak of the global dimension of a "digital age" and in the same breath of the associated deep structural changes, yet then hope to explore the architecture – designed and produced with the tools of the very same age – by broadening concepts that are limited to the status of *new* or *digital* technology?

To finalize, the third hypothesis, to which the first two arguments conflate, is based on the assumption that the deep structural changes brought on by the influence of information technological on architecture can be better understood if one begins by considering pattern theory and not ornament theory. One thus completes a type of castling, where the accent is shifted between different but nonetheless related theories.

37 See footnote 35, p. 82.
38 "Every procedure that can be described formally can be presented as a function of a symbolic machine and – in principle – can also be completed by a real machine." "Jeder Vorgang, der formal beschreibbar ist, kann als Operation einer symbolischen Maschine dargestellt und – im Prinzip – von einer wirklichen Maschine ausgeführt werden." Sybille Krämer: *Symbolische Maschinen. Die Idee der Formalisierung in geschichtlichem Abriss* (Symbolic machines. The idea of formalization. An historical survey), Darmstadt 1988, p. 3.
39 See footnote 8. The oversized metal frame in Arata Isozaki's design for the new Florence train station and the DAM Pavilion by Barkow/Leibinger are mentioned here as examples of new ornament.

Behind these three theories is the idea that one can perhaps more thoroughly reflect on the architecture designed in and for a technically networked world with structural concepts in which, firstly, meaning is abstracted to the greatest degree possible and, secondly, operationalization is more or less possible. The idea of the *pattern,* with its potential meaning as a design pattern that can be formalized, comes far closer to meeting these criteria than the idea of the *ornament.* It seems as though Alexander's carefully crafted language of structures and patterns is now being employed in digital architectural production, even if it still sounds purely technical and its rhetoric is still largely about the feasible. It would hence be important to demonstrate – and a worthy continuation from this point forward – how one might revive and continue to critically uphold the humane and social aspects of Alexander's very promising world of patterns for architecture.

Fabian Scheurer

ARCHITECTURAL ALGORITHMS AND THE RENAISSANCE OF THE DESIGN PATTERN

"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."[1] This was written by Christopher Alexander in his publication *A Pattern Language* in 1977. His statement formed the basic principle, referred to as the "design pattern," for a formal interpretation and abstraction of the architectural design process. It was based on the fundamental idea that the problem pattern, meaning recurring problems in the architectural design and planning process, should be abstracted situationally and functionally and assigned the appropriate solution patterns. Since these individual patterns relate to one another, a complex hierarchical network is formed of 253 interrelated patterns that should collectively present a formal, practical guideline for the architectural design process. Alexander's pattern language caused quite a stir back then, but it was not integrated into architectural practice. Yet ten years after Alexander's publication, the American computer scientists Kent Beck and Ward Cunningham applied his theory to problems in software engineering.[2] That is how the pattern language, originally conceived as a system for architectural design, was eventually applied to the world of computer science – which at that point was experiencing a paradigm shift caused by what are known as object-oriented programming languages.[3] Applying the pattern

1 Christopher Alexander, Sara Ishikawa, and Murray Silverstein: *A Pattern Language,* New York 1977, p. x.

2 Kent Beck and Ward Cunningham: *Using Pattern Languages for Object-Oriented Programs,* Technical Report No. CR-87-43, 1987.

3 Unlike their predecessors, which dealt separately with stored data and the functions needed to process it, object-oriented programming merged these two aspects into what are called objects. The only way to change the stored data (properties) of an object is to apply methods that the object itself provides. The inner life of an object, that is, the implementation of the actual functionality, remains completely hidden from the curious eye of the outer world (referred to by programmers as encapsulation). This has the advantage of allowing the inner construction of the object to be changed at will (by applying an efficient algorithm) without affecting a neighboring object. See Alan C. Kay, "The Early History of Smalltalk," in: *ACM SIGPLAN Notices,* Vol. 28, No. 3, Association for Computing Machinery, New York 1993, p. 69 ff.

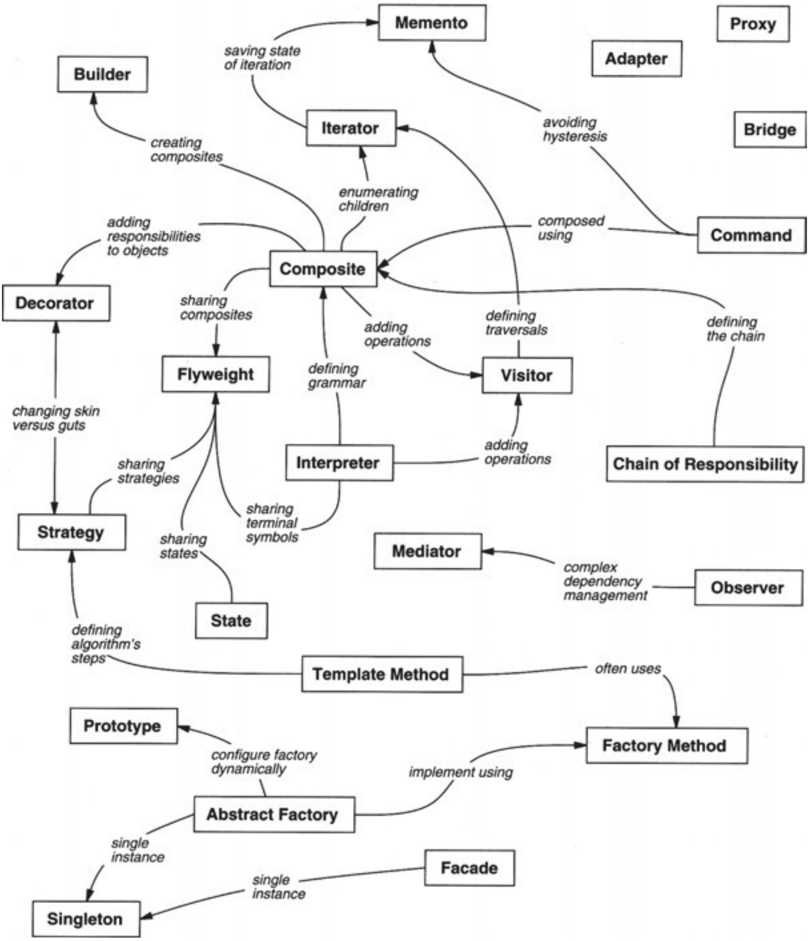


Fig. 1: Gamma et al.: Software Design Patterns: the 23 software design patterns and their interactions.

language to computer science is attributed principally to Swiss computer scientist Erich Gamma who, in 1994, together with his American colleagues Richard Helm, Ralph Johnson, and John Vlissides,[4] published *Design Patterns: Elements of Reusable Object-Oriented Software,*[5] still seen today as the seminal work in its field [Fig. 1]. Although in architecture, "the pattern language was an obvious failure, even measured against its own objectives,"[6] it became an extremely effective and successful concept for software development in computer science. Architects hotly debated the reasons for the concept of pattern formation being initially unsuccessful in architecture, but not why it seemed so much better suited to designing software than buildings.

Today, thirty years after publishing *A Pattern Language,* Alexander's design pattern appears to have returned to its original domain – albeit on a completely different level – after enjoying a successful detour through computer science. The objective of the following essay is to present the history behind this return by highlighting specific examples. However, the issue of programming will be discussed in more depth than the issue of architecture. It is more instructive – despite, or perhaps precisely because of the apparent differences between architectural designs and software designs – to attempt to draw conclusions and to explore possible analogies between the two, to ask whether advancements in computer science might be helpful in developing new ideas for designing and building architectural constructions, and to examine whether design patterns could be applied to computer-aided design, the field that merges the two.

A Question of Abstraction

Comparing Alexander's *A Pattern Language* with Gamma's *Design Patterns* initially reveals a quantitative difference: Gamma describes twenty-three software patterns and divides them into three thematic groups; Alexander describes thirty-six subgroups and 253 design patterns [Fig. 2]. Even though comparisons between architecture and software are limited, the question still arises as to

4 Called the "The Gang of Four."

5 Referring to Alexander, they identified twenty-three creational, structural, and behavioral patterns of software programming. Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides: *Design Patterns – Elements of Reusable Object-Oriented Software,* Amsterdam 1994.

6 Christian Kühn: "Christopher Alexander's Pattern Language," in: *Arch+,* No. 189, 2008, p. 27.

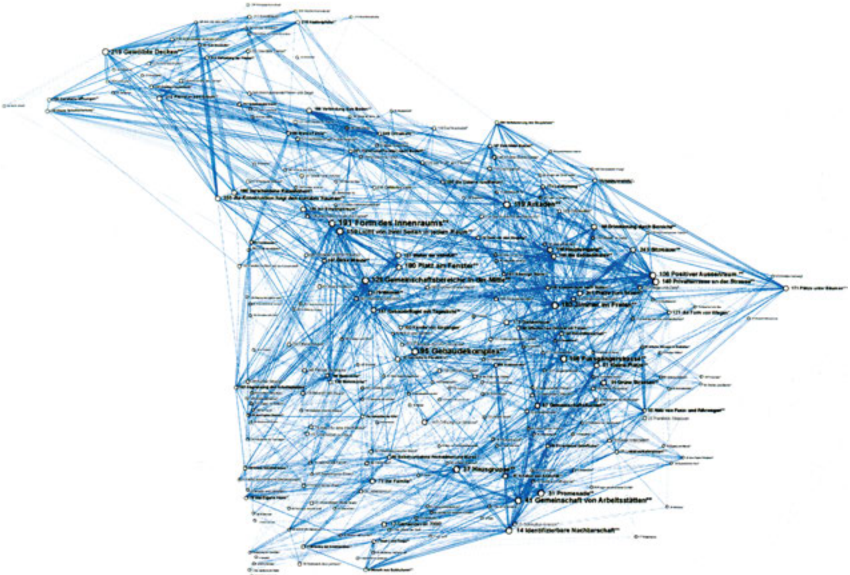


Fig. 2: The 253 architecture design patterns and their correlations. Christopher Alexander: *A Pattern Language.*

why one discipline would require eleven times as many design patterns as the other. Yet, closer examination reveals great qualitative differences between the two approaches. Alexander divided his patterns according to scale into three groups: urban planning, buildings, and construction. He defines ten design patterns for just the various spatial functions in a residential space: from the open-plan kitchen to the closet. All of his patterns are based on criteria that are important to the users (residents) of the house or apartment. Although Gamma may also use a concrete application program[7] as an explanatory example, the design patterns are fundamentally conceived independent of the type and dimensions of the software and its specific application. They relate basically to the dependencies and the flow of information and control within the software, but not to a concrete use, such as word processing, drawing programs, or chart calculations. Accordingly, these patterns are also independent of the software users' requirements and refer to categories that are more important to the software's programmer. The design patterns for software and architecture differ very much in relation to dimensionality, the degree of abstraction, and the target group within the field of interest.

Scalability versus Dimension

Let us first examine the problem of dimension. Alexander's design patterns cover an enormous range, from urban planning to construction. The examined structures span over six different orders of magnitude – from kilometers to millimeters in size! Even if some basic principles can be observed independent of dimension, and everything is based on the fundamental *human* dimension – which was particularly important to Alexander – it is amazing that his design language consists of only 253 patterns, despite its universal ambitions.

There are also comparable stages of observation in computer systems. One of the basic principles in computer science is the subdivision of complex, complete systems into compounded, interdependent layers, as for example in *hardware, system software,* and *application.* The greatest difference between this and architecture is that the same components and methods are used

7 An example here is the so-called WYSIWYG (what you see is what you get) editor used to process and file word documents and images. Gamma, 1994, p. 33.

within these layers, despite the different levels of abstraction. A hardware driver, an operating system, and a word processing system can all be implemented in the same programming language. The layers do not present any shift in dimension, but rather serve as the principle of order, and thus neatly separate individual responsibilities and make them accessible only via defined interfaces. This is the only way to run, for example, a CAD-program on different operating system/hardware combinations without having to adapt the program. Modern programming technologies even make it possible to view complete application programs as objects and thus, for example, to integrate spreadsheet software as an object into another program.[8] That means that the structure of the program, regardless of its degree of detailing, is *self-similar.* Software can be scaled at will, at least while it is being programmed, without any need to change the basic patterns – unlike architecture, where methods change fundamentally with the respective dimensions.

Abstraction versus Application

Alexander's patterns largely refer to concrete application problems from the perspective of the end user – the resident. They address the needs of families, couples, singles, teachers and students, children and teenagers. Qualitative specifications are also occasionally made, such as the maximal number of levels in pattern No. 21, the "four-story limit."[9] Contrary to this principle, Gamma's software design patterns are completely free from the actual application and are wary of making any quantitative assertions.[10] The patterns are not only independent of scale, but also of purpose and the size of the software. They can be applied without changes in the development of word processing software, CAD programs, or MP3 players. They also do not affect the design and the functionality of the user interface, but rather only their implementation in the software's inner system.

8 In object-oriented programming, encapsulation does not allow the question concerning the effort (the number of lines of code) needed to implement an object to be clarified from the outside. The size of an object is thus defined by the number of its methods.

9 "In any urban area, no matter how dense, keep the majority of buildings four stories high or less. It is possible that certain buildings should exceed this limit, but they should never be buildings for human habitation." Alexander, 1977, p. 119.

10 Except in the case of the "Singleton" pattern, which ensures there is exactly one instance of a class. Gamma, 1994, p. 127.

This emphasizes once again that the basic motivation of software patterns is the abstraction of concrete applications and quantities. They serve mainly to create approaches for one of the basic problems occurring in software engineering: the strict division between programming and execution.[11] In architecture, despite the many advancements that have be made in the computerized prefabrication of building components, it would be inconceivable for the planning of a project (regardless of scale) to be completed and documented before a machine begins to automatically translate this plan into a built reality without the use of human input. But this is exactly what happens during the process of producing software. Computer programs are formulated in a programming language and then compiled[12] automatically into an executable program. Because of the degree of abstraction, they can be developed without much knowledge of the concrete application at runtime. In the development stage, the programmer will try to make as few assumptions as possible, and shift as many concrete decisions to the runtime as possible. Nevertheless, all objects and their methods have to be previously specified in a clear formal language, as this is the only way the automatic compilation of the code lines can be successfully executed at a later date.

Object-oriented program languages solve this problem by not defining concrete objects, but rather object classes from which concrete instances are derived at runtime. But this can get difficult if it is not known during the development to which class the later-created objects belong, or how they might influence one another. In order to be able to still treat different classes in the same manner, object-oriented programming defines a particular abstraction mechanism known as inheritance. Classes can be derived from other classes, referred to as super classes, and inherit their attributes and behavior. All instances of the derived classes can be manipulated by the methods defined in the super class without further adjustments [Fig. 3].

The task of defining such class taxonomies and their intelligent interconnection is one of the main objectives of designing object-oriented software. This can soon become extremely confusing in complex applications, such as Graphical User Interfaces (GUI) for various runtime environments. This is precisely where software design patterns come into play by suggesting the

11 The time of implementation is referred to as runtime.
12 The time (but not the duration) at which the translation takes place is referred to as compile time.

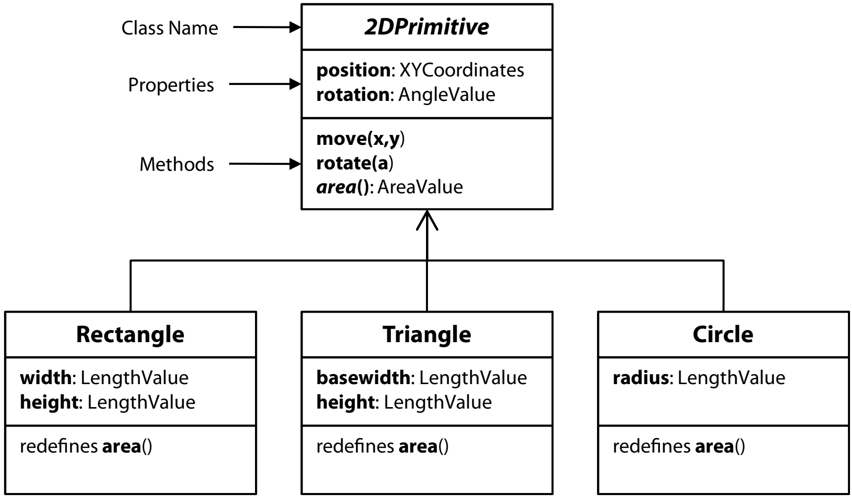


Fig. 3: The properties and methods defined in abstract class *2DPrimitive* are valid for all subclasses. The three subclasses *Rectangle, Triangle,* and *Circle* inherit these and add their specific properties. The methods area to calculate the surface is available in all classes. They are however redefined in each subclass, because the type of calculation is different for each geometric form.

appropriate solution patterns for recurring problems and help shift concrete decisions to runtime.[13]

Time-related problems of this sort also often arise at certain points during an architectural design process. For example, decisions regarding the form of a building are often made before those regarding its construction and production methods. This approach may well seem sensible when dealing with standard buildings, but can lead to problems as soon as standard solutions are not available [Fig. 4]. In order to apply a design pattern in such cases, the pattern language would need to be expanded accordingly – which is what Alexander explicitly recommends,[14] but this runs the risk of becoming arbitrary. Another alternative would be to apply the abstraction level of software design patterns to architecture, and organize the design or construction process as a whole, rather than as a single concrete building task. This also means, however, defining the patterns for the interaction between the involved parties as well as the roles they take on, which in turn means relegating the architect's function to project manager, and not designer.

Top-down versus Bottom-up

Why are Alexander's design patterns so concrete? One of his declared intentions was to enable the end user to create the design patterns for his or her own built environment. Although he does not use the term explicitly, it is clear that his architectural principle is emergence! The overall structure should develop from a collaboration of many local and individual interventions made by the parties involved; it should be a global pattern with a quality that pervades all dimensional levels and is more than the sum of its parts: "This quality in buildings and in towns cannot be made, but only generated, indirectly, by the ordinary actions of the people, just as a flower cannot be made, but only generated from the seed."[15] This bottom-up approach became popular in both system theory and as a field of research in computer science virtually parallel with the advent of *A Pattern Language.*

13 One interesting example here is the "abstract factory" pattern. See Gamma, 1994, p. 87.

14 "If there are things you want to include in your project, but you have not been able to find patterns which correspond to them, then write them in, at an appropriate point in the sequence, near other patterns which are of about the same size and importance." Alexander, 1977, p. XXXIX.

15 Christopher Alexander: *A Timeless Way of Building,* New York 1979, p. 157.

Fig. 4: Zaha Hadid: *Hungerburgbahn,* Innsbruck. The form prior to construction: it took the construction engineers several elaborate attempts before they could devise a plan to realize Hadid's design for the four stations of the Innsbruck Hungerburgbahn.

The well-received work on "evolutionary strategies,"[16] published in this context by German computer scientist Ingo Rechenberg, and on "genetic programming"[17] by American computer scientist John Holland, were written around the same time and may have influenced Alexander.[18]

In fact, however, the bottom-up approach does not have much to do with day-to-day work of software engineers. In most areas, programming is a top-down process: large problems are reduced for so long and broken down into ever-smaller units until they eventually dissolve. Accompanied by methodical test phases, partial solutions are gradually integrated into one complete solution. Bottom-up methods such as genetic algorithms are only applied, albeit with a certain amount of caution, as an optimization strategy in a few areas that have a very large solution space.[19] Only in a small number of cases do they possess the most important property of a good algorithm: first, the robustness needed to lead to a solution even under difficult starting conditions within the given time and second, to preferably always arrive at the same solution with the same starting conditions.[20]

Despite all this, the bottom-up principle has recently become popular in computer science as well [Fig. 5]. Participative software, under the catchword Web 2.0, made a point of the concept of user participation. In order to create reference websites such as Wikipedia, the collective intelligence of users is channeled and then employed to collect and filter an astounding amount of data. But this should not confuse the issue: none of this occurs during the design phase; it all happens during the runtime. That which allows the users to interact with the underlying objects by means of a user interface may well be

16 See Ingo Rechenberg: "Evolutionsstrategie – Optimierung technischer Systeme nach Prinzipien der biologischen Evolution" (Evolution strategy: Optimization of technical systems according to the principles of biological evolution) (PhD thesis), 1971.

17 See John H. Holland: *Adaptation in Natural and Artificial Systems: an Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence,* Ann Arbor 1975.

18 Christopher Alexander studied both architecture and mathematics.

19 The term solution space implies the entirety of the possible solutions for a problem. When it is very large, it is often difficult to arrive at the best possible solution (global optimum) within a practical timeframe, meaning one has to be satisfied with a sufficient solution (local optimum).

20 It is easy to understand that this concept would be completely rejected in architecture, especially given the second "property," that is the notion of always arriving at the same solution! It might, on the other hand, explain why architects have always been so fascinated by Artificial Life methods – even if they have seldom been successfully applied in design, as with Christopher Alexander's design pattern. See John H. Frazer: *An Evolutionary Architecture,* London 1995.

Fig. 5: Bottom-up-design: The CAAD/ETH Zurich Pavilion at the Swissbau-Messe 2005. The sructure of the pavilion was optimized using artificial life methods. The structural mesh is shaped in a dynamic process by interaction between the individual hubs themselves and their surroundings (the openings and the spherical facade). The various nodes are shifted and added in accordance with certain regulations until specific structural specifications are fulfilled.

the result of design patterns. Yet because users are only able to see the software after it has already been compiled, they will never have any direct contact with the actual design patterns.

Models, Geometry, and Meaning

Both architecture and computer science deal with specific segments of reality. Be it a built environment or efficient software – both aim to fulfill an actual purpose. But how does the reference to this reality look during the design phase? Standard CAD plans are merely a collection of lines and symbols, as are plans on paper. And even three-dimensional CAD models are simply geometric objects. Only the final result of the architectural design process, which means a geometric representation, is actually stored, and it does not yet contain explicit information concerning the meaning or purpose of the objects and symbols.[21]

All of this could soon change however. Building Information Modeling (BIM) plays a paradigmatic role in this context. The models that result from this method store not only the *geometry* of buildings, but also their *meaning.*[22] Object orientation forms the basis of this principle as well. A wall object has access to information concerning its attributes, such as *thickness, height,* and *length.* An appropriate *door object* knows its own properties, but also those of the wall object that surrounds it. This produces a semantic model that is more than a geometric illustration of the design; it can be read and evaluated by machines, thus allowing information not explicitly defined while designing the model to be automatically extracted in a variety of ways.[23]

The next step in this development is to store the origins of the objects in the model along with their *properties* and *meaning.* This is done by evaluating individual interdependencies between objects: if for example a door object knows the wall object that surrounds it, the door object is able to automatically adjust the thickness of its frame to match that of the thickness of the wall. The properties of the objects thus become parameters that can be manipulated and adjusted by other objects: the model becomes an *associative, parametric model.*

21 The viewer first has to interpret their meaning, which requires human intelligence and expert knowledge, thus virtually excluding an automatic processing of such plans.
22 Chuck Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston: *BIM Handbook – A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors,* New Jersey 2008.
23 The concrete objects that make up a BIM model are also derived from object classes, for which there are pre-existing collections such as the Industry Foundation Classes (IFC).

Architects Design Algorithms: The Return of the Design Pattern?

Parametric models are basically algorithms. On the one hand, the demands on the designer change, because much of the information that was until now implicitly hidden in plans that had room for interpretation, now has to be explicitly formulated into specific parametric models. On the other hand, designing parametric models is subject to the same rules of complexity[24] and computability[25] as software engineering. The naïve approach of storing as much information as possible in one model does not generally lead to a solution, but rather to models that are unmanageably complex and, ultimately, of no value. For the architectural context, this implies that the actual art of creating a parametric model is to find the correct level of abstraction, which means entering only the most necessary information and correlations into the model and omitting as many unnecessary details as possible. This particular objective of the minimal model is only partially compatible with the need to react flexibly to changes in the design. The choice of parameters and their dependencies predefines a certain solutions space within which the model can operate. Any further changes require an adjusted or completely rebuilt model. Wide-ranging decisions have to be made in advance without full knowledge of the later application. As is true in software engineering, design patterns can also be a helpful instrument here in determining the correct balance between efficiency and flexibility.

Designing associative, parametric models is a new field that is situated directly on the border between computer science and architecture. A new professional discipline is now developing precisely in this area, namely on the border between architecture and engineering[26] as well as in independent

24 Algorithmic complexity is named after the Russian mathematician Andrej Nikolaevič Kolmogorov, who defined a measure of complexity based on the most compressed description of a string. See Kostas Terzidis: "Algorithmic Complexity: Out of Nowhere," in: *Complexity. Design Strategy and World View,* in the series: *Context Architecture: Key Concepts between Architecture, Art, Science, and Technology,* Basel, Boston, Berlin 2008, p. 75–86.

25 Computability signifies the existence of an algorithm that will lead to a solution to a specific problem within a finite amount of time. A closely related question deals with how many resources are needed to calculate such a solution. (See Alan M. Turing: *On Computable Numbers, with an Application to the Entscheidungsproblem,* Proceedings of the London Mathematical Society, Series 2, Vol. 42, 1936, pp. 230–265.)

26 For example the *Specialist Modeling Group (SMG)* in Norman Foster's practice or the *Advanced Geometry Unit (AGU)* of ARUP engineers.

consulting firms.[27] Regarding architecture, working with parametric models constitutes a departure from the traditional working method of Computer-Aided Architectural Design as a digital drawing table. One might even go so far as to describe this departure as a paradigm shift, comparable to the shift that occurred when object-oriented programming was first introduced to computer science. These innovative methods open completely new possibilities, such as overcoming standardization and designing complex forms for facades that have to be assembled from thousands of single components. Yet the necessary models here can also soon become overly complex, as can be seen in computer engineering, and thus threaten to reverse the progress made. Fundamental knowledge of all the relevant fields of expertise and a high level of experience is needed in order to successfully meet the challenge of designing parametric models – these are skills that take a long time to develop and that are very difficult to communicate.

The Alexander-influenced software design patterns, developed in computer science, were an effective tool that helped programmers solve precisely these structural tasks and focus more on important, content-related issues. There are already attempts to formulate design patterns that will aid the production of parametric models[28] and, bearing the above-mentioned parallels with software engineering in mind, it promises to be a very effective approach. Alexander's pattern language is undoubtedly returning to architecture – however, not as a tool for architectural design, but rather for describing the design in the formal language of associative, parametric models.

27 Such as *Gehry Technologies,* the spin-off of Frank Gehry's practice, and the smaller German/Swiss practice *designtoproduction.*
28 See Robert Woodbury, Robert Aish, and Axel Kilian: "Some Patterns for Parametric Modeling," in: *Expanding Bodies – Proceedings of the ACADIA 2007 Conference,* Halifax 2007.

Christoph Hölscher

WAYFINDING STRATEGIES AND BEHAVIORAL PATTERNS IN BUILT SPACES

We experience architectural spaces by perceiving them in different ways and by moving through them; our presence brings the space to life. Finding our way through buildings and urban spaces is an activity that we tend to become aware of only when something goes wrong: when we take a wrong turn, for example, or literally lose our way. For architects who design theses spaces, understanding patterns of human orientation behavior presents a challenge for very pragmatic reasons. If a building or an urban area is difficult to navigate, it will quickly become unpleasant; furthermore the original architectural concept and the associated functional requirements may fail to fulfilling their purpose.[1]

The concept of usability has been familiar in the context of what is known as human-machine interaction since the 1990s. Today, few successful digital products are released on the market before they are subjected to user tests and analyses. Creating a cognitive harmony between the designed product and the consumer has become a matter of course.

However, this is not the case in architecture. There are certainly many reasons for this, starting with the aesthetic and creative requirements, but also residing in the fact that buildings must fulfill a multitude of diverse functions and expectations, whereas the functions of electronic artifacts can usually be defined much more clearly at the outset. Architects rely largely on intuition with regard to enabling, controlling, and promoting human movement and orientation processes in buildings; nonetheless, there is a clear parallel between human-machine interfaces and human-environment interaction. In an era of evidence-based approaches to architectural design – take hospitals, for example – incorporating empirical studies, particularly cognitive-psychological research, into the design process and basing the concept on scientific findings seems increasingly warranted, at least with regard to the essential aspect of human orientation.

1 Gary W. Evans and Janetta Mitchell McCoy: "When Buildings don't Work: The Role of Architecture in Human Health," in: *Journal of Environmental Psychology,* 18, 1988, pp. 85–94.

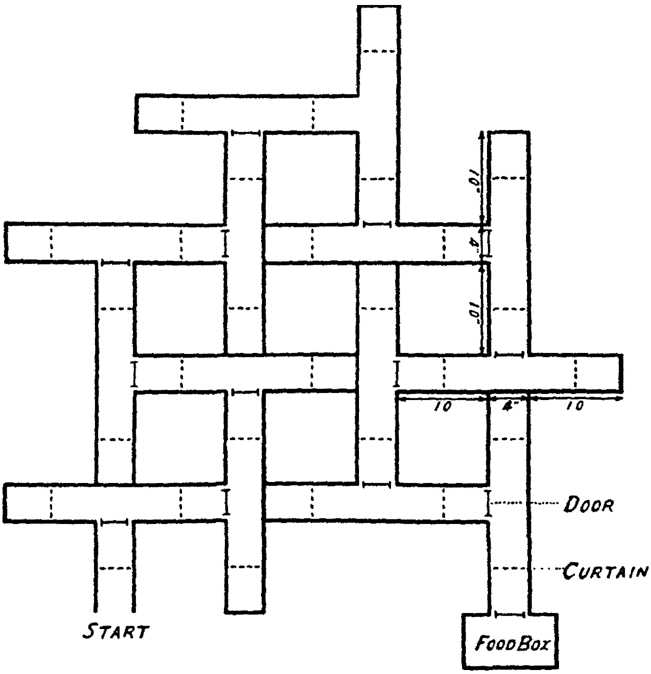


Fig. 1: Classic labyrinth used to research spatial cognition in rats.

The following will first concentrate on the historical development of the relationship between psychology, architecture, and space; then the focus will shift to examining the various possibilities offered by the repertoire of modern scientific analysis, before finally investigating the challenges posed by integrating scientific findings into the architectural design process.

From Laboratory Rat to Human Behavior in Buildings

Over the last sixty years, the development of research on behavior and cognition reveals that different parallel paths have emerged since the 1940s, which now – in part due to powerful digital tools – form the basis for our knowledge of patterns of spatial behavior.

Empirical examination of the cognitive processes involved in spatial learning, and the orientation behavior on which this is based, can be traced in psychology to the early work of the American psychologist Edward Tolman,[2] who introduced the concept of the “cognitive map.” Using animal experiments, he was able to prove that rats do not in fact learn simple patterns of stimulation and response – as assumed in classic behaviorist learning psychology – but rather develop a very complex “mental representation” of their spatial environment (labyrinths are usually employed for experiments) that helps them to rapidly identify short-cuts. This is a behavioral pattern that would hardly be possible without a mental representation of a spatial configuration [Fig. 1]. Since then, the structure and content of this cognitive map[3] in humans and animals has been researched in countless studies, proving that the mental representation does not constitute a true image of the spatial environment, but is instead subject to systematic distortions and simplifications.[4]

In the architectural context, American architect and urban planner Kevin Lynch[5] established a method of mentally mapping urban space. Lynch wanted

2 Edward C. Tolman: “Cognitive Maps in Rats and Men,” in: *Psychological Review,* 55(4), 1948, pp. 189–208.

3 Despite what is suggested by the term cognitive map, the mental representation in our minds is to be understood only metaphorically as a map, because it does not represent Euclidian distances between places and their relative location as true-to-life. There is also some question as to whether we are dealing with pictorial representations.

4 These phenomena have also been studied in detail by the American psychologist Barbara Tversky. See Barbara Tversky, “Distortions in cognitive maps,” in: *Geoforum,* 23, 1992, pp. 131–138.

5 Kevin Lynch: *The Image of the City,* Cambridge, Mass. 1960.

to understand how people categorized their environment and how this information was stored in memory, which he called the "image of the city." This legibility, meaning the architectural decipherability of a built configuration, was identified as one of the basic requirements needed to navigate through cities or complex buildings. Lynch also referred to classic psychological works; thus findings from Gestalt psychology theories helped him to develop criteria on how humans mentally segment, comprehend, and learn about cities. Using empirical studies, he developed elements called paths, edges, districts, nodes, and landmarks that are meant to serve as the basic vocabulary of mental urban maps. Lynch considered a city "legible" if this basic vocabulary resulted in a distinctive city structure that inhabitants could both recognize and use for orientation.

A second direction in research aimed at the mental processing of environmental stimuli is strongly based on visual perception theories and cognitive representation. In the 1950s, American psychologist James J. Gibson[6] pointed out that the human (and animal) system of perception is evolutionarily organized in a manner that enables it to recognize environmental attributes, such as spatial depth or movement, directly from invariants in the visual input. Gibson coined the term "affordance" in his book published in 1979, *The Ecological Approach to Visual Perception.* This describes the attributes of an object or a complex constellation of stimuli that suggest certain courses of action, such as the sense of "invitation" conveyed by a door handle to turn it and enter another space, or – in relation to spatial configuration – the attributes of a branch in a corridor that enables visitors to explore and acquaint themselves with a space. The concept of affordance was popularized largely by the American cognitive scientist Donald Norman[7] for the fields of ergonomics and user-friendly designs of computer systems. As previously mentioned, the concept can be applied to the geometric aspects of architectural spaces, such as spatial shapes, as well as to ground plan configurations, lighting, and signage or orientation systems.

6 See James J. Gibson: *The Perception of the Visual World,* Boston 1950. Id.: *The Ecological Approach to Visual Perception,* Boston 1979.

7 Donald A. Norman: *The Psychology of Everyday Things,* New York 1988.

The *Dalandhui Conference*[8] in the spring of 1969 marked the beginning of institutionalized architectural psychology in Europe. Architects and psychologists at the University of Strathclyde collaborated for the first time on a grand scale to systematically research the interplay between architectural spaces and human behavior, thought processes, and experience. Interestingly, the initiative for this innovative research field was launched by the faculties of architecture with the express purpose, at that time, of integrating psychologists and sociologists into their research and curriculum. In the 1970s and 1980s, this approach formed the basis of an interdisciplinary culture of design and scientific empiricism that found its intellectual home particularly in the American *Environmental Design Research Association* (EDRA) and its European counterpart, the *International Association for People-Environment Studies* (IAPS).

In the 1980s, various architect/psychologists with interdisciplinary training, such as Romedi Passini from Italy, Tommy Gärling from Sweden, and the American Gerald Weisman, built bridges between cognition and architectural psychology. They presented wayfinding models that were more or less convincingly substantiated on an empirical basis, and drew solid connections between cognitive factors and physical environmental attributes.

Passini[9] examined wayfinding in large, rambling, and partially subterranean shopping malls in Montreal, and understood wayfinding as a cognitive process of decision-making by which a rough path is first planned between the starting point and the destination, and then refined and readjusted "along the way." This involves both concrete, previous knowledge about the building in question, and general knowledge about building types and functions. Passini's model is based on the detailed observation of his test subjects' motion paths, plus the analysis of verbal expressions used to comment on decisions made at selected waypoints ("thinking aloud").

8 Named after Dalandhui House of the University of Strathclyde in the Scottish countryside. This is also where initial studies were presented on the influence of corridor layouts on navigation difficulties in public buildings. See "Architectural Psychology: Proceedings of the conference held at Dalandhui, February 28th–March 2nd 1969," publ. by David V. Canter, London 1970.

9 Romedi Passini: *Wayfinding in Architecture,* New York 1984. Id.: "Wayfinding Design: Logic, Application and Some Thoughts on Universality," in: *Design Studies,* 17, (3), 1996, pp. 319–331.

For his part, Weisman transferred Kevin Lynch's urban planning philosophy to architectural interiors and compiled a taxonomy of environmental attributes that have a direct influence on the cognitive process of wayfinding and local wayfinding decisions.[10] He distinguished the following four categories: visibility, which comprises the options for action and which relative part of the building is visible from one standpoint; signage, which refers to a primarily non-architectural element that contains explicit semantic codes about destinations and building structure; architectural differentiation, which involves determining similarities between certain areas of buildings; and lastly, the complexity and configuration of a ground plan, that is, the location of rooms and corridors in relation to one another, as well as the number and arrangement of intersections, junctions, and, hence, decision-making points.

While the first three categories can be operationalized[11] rather clearly, the question regarding the nature of complexity[12] proves multilayered and ambiguous. Weisman compiled a subjective assessment of the complexity of ground plans by asking test persons to complete questionnaires, but did not unambiguously link these assessments to concrete, physical building attributes. Since then, methodological strategies, such as those formulated by Passini, have been further refined. The core question here is which cognitive decision-making processes and strategies can be recognized in individual patterns of motion behavior.[13] A combination of different simulation technologies, such as *space syntax* or *virtual reality,* makes it possible to calculate and predict human patterns of behavior in architectural spaces.

10 Gerald Weisman: "Evaluating Architectural Legibility: Wayfinding in the Built Environment," in: *Environment and Behavior,* 13(2), 1981, pp. 189–204.

11 In the behavioral sciences, the term operationalize implies the transfer of theoretical concepts into measurable and thus more objective parameters.

12 For a current discussion of the complexity concept see Andrea Gleiniger and Georg Vrachliotis (eds.): *Complexity: Design Strategy and World View,* in the series *Context Architecture. Architectural Concepts in Art, Science and Technology,* Basel, Boston, Berlin 2009.

13 In other words, we are dealing here with various levels of *patterns:* the patterns of motion behavior (as behavior patterns that can be directly observed) are underpinned by patterns of decision-making behavior that are based on cognition and are thus rendered theoretically tangible via verbal substantiation and an understanding of the surrounding spatial structure.

The Syntax of (Behavioral) Space

The term space syntax encompasses a series of analytical methods that describe and interpret spatial configurations, developed at the Bartlett School of Architecture of University College, London since the 1970s.[14] The historical starting point for this area of research comes from a perspective that is more sociological than cognitive, meaning that the behavior of an entire group is studied rather than that of one individual. Space syntax is therefore particularly useful in researching the motion paths of pedestrians in cities or tour groups in museums, for example. Each analysis begins by methodically breaking down complex building configurations into geometric-spatial elements, such as corridors or city squares. The connections between these elements can be presented as a network of differing navigation and decision options. The spatial visual axes play a decisive role and define the section of the space that can be seen from a given position [Fig. 2 and 3]. The architectural space is reduced to a network structure of the individual elements, and this structure can be expressed in a graph. These formal elements make the architectural space accessible to a broad number of other mathematical analytical means that, in turn, can examine "which role" a certain part of the terrain assumes in the spatial network, as well as its local connectivity and global integration. These methods make it possible to use the distribution of connectivity and integration so as to calculate the number of people, and predict who will walk along a certain place (street, building, or corridor).

Since the beginning of the 1990s, work done by several research groups has shown[15] that cognitive – that is, individual wayfinding – behavior can be described by applying the originally group-based analytical procedures of space syntax. For this reason, the integration of space syntax into cognitive psychological methods of observation and analysis are illustrated in the case study that follows.

14 Bill Hillier and Julienne Hanson published the central book on this subject: *The Social Logic of Space,* Cambridge 1984.
15 See the special edition of *Environment & Behavior,* published by Ruth Conroy Dalton and Craig Zimring, Vol. 35, No. 1, 2003.

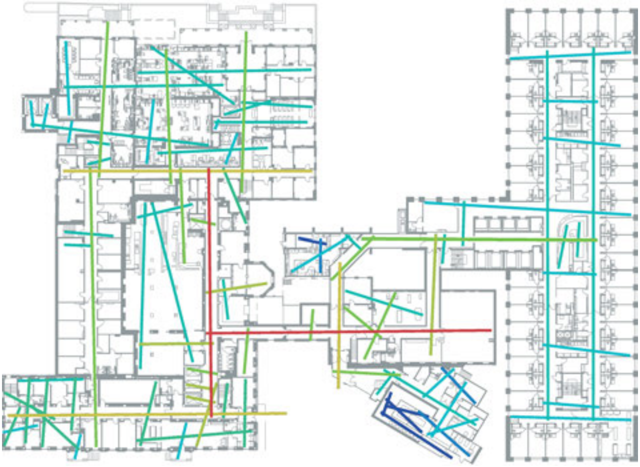


Fig. 2: Visual axes in a hospital complex; the different colors represent gradual variations in integration respective to the centrality in the building.

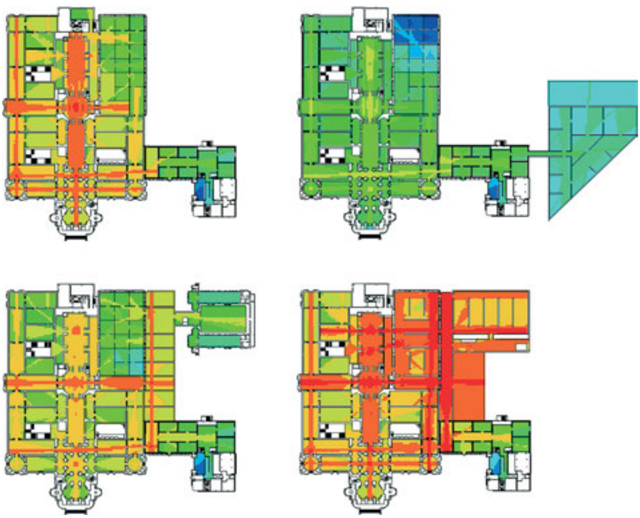


Fig. 3: Tate Gallery, London. In this space syntax analysis, areas where a high level of traffic is predicted are identified in red, while blue is used to denote low level traffic predicted.

A Convention Center as Navigation "Test Lab"

Human spatial wayfinding strategies were examined in a series of studies at a convention center.[16] The building was constructed in 1970 as a multifunctional center with a correspondingly complex spatial structure, which made it particularly suitable for identifying navigational strategies as well as the specific aspects of design that cause so-called usability hotspots, that is, points in a building that prove difficult to navigate.

The studies resulted in two proposals for a cognitive expansion of space syntax methods. These will make it possible to correlate psychological findings, based on observing test persons, to objectively identifiable criteria of a built environment, thereby examining the influence of specific architectural features on human behavior. One suggestion involves developing a detailed modeling of the visibility in building stairwells, because stairwells are the vertical connecting channels and thus play a vital role in overall spatial navigation. The second proposal relates to the fact that a study of entire decision-making sequences (or routes, that is, pathways that link or connect different spaces) proved to be as significant as the study of individual places. For this reason, route specific measures were developed that made it possible to reliably calculate and predict any potential difficulties involved in finding certain places in buildings.[17]

Different options for selecting a route to a given destination were available to the test subjects during the experiments. Having to change floors a certain amount of times was planned in order to ensure that the test had the highest level of realistic complexity. Test subjects with previous knowledge of the building chose to find their way directly, whereas the test subjects, who had to investigate the building first, used obvious and more centrally located points such as the entrance area of the building. When these aspects were checked with space syntax, the different patterns of behavior were also reflected in the calculated connectivity and integration data.

16 See Christoph Hölscher, Tobias Meilinger, Georg Vrachliotis, Martin Brösamle and Markus Knauff: "Up the Down Staircase. Wayfinding Strategies and Multi-Level Buildings," in: *Journal of Environmental Psychology 26* (4), 2006, pp. 284–299.
17 Christoph Hölscher, Martin Brösamle, Georg Vrachliotis: "Challenges in Multi-level Wayfinding. A Case-study with Space Syntax technique," in: *Environment and Planning B: Planning & Design,* 2009.

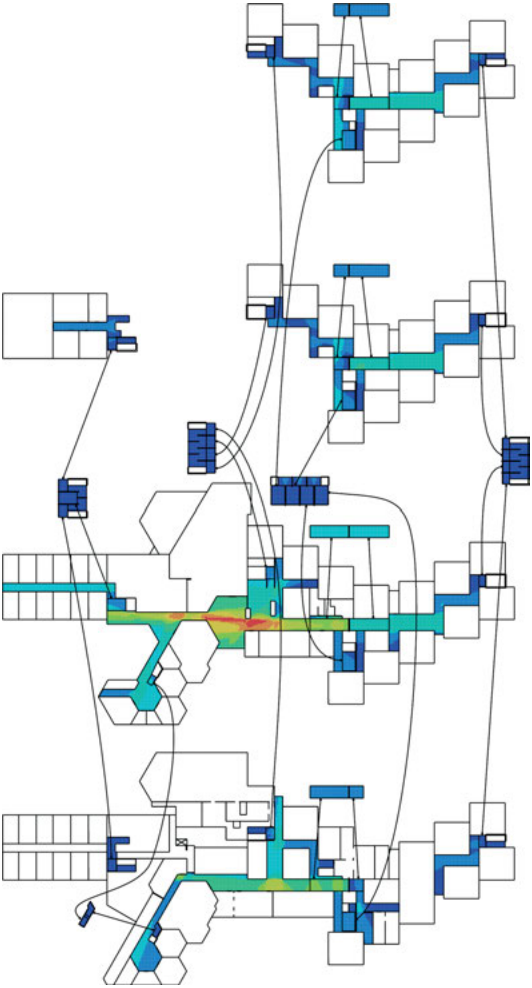


Fig. 4: Case study conference center: the darkness or lightness of the areas represents the local connections of individual sections to the spatial network. Dead-ends appear as dark areas in the basement and fringes of the building, central areas are lighter in color. Heterogeneously distributed statistical values in and between the levels indicate potential inconsistencies that may hamper navigation and orientation.

A building analysis revealed a series of cognitive problems that can also be calculated with space syntax. The entrance area and the stairwells in their function as vertical connecting channels proved to be particularly difficult places [Fig. 4]. Dead-ends in the basement and significant variations in the layout of the upper levels presented further difficulties in the building; these challenges can be illustrated by both local syntax indicators and the global intelligibility measurement.

From Scientific Findings to Design Practice

How can these empirical findings be applied to practice? Results from similar experiments on the perception of building structures clearly show that humans base their spatial orientation on three factors: on the qualities of a certain spatial situation; on their overall previous knowledge of the building; and on their schematic assumptions with regard to the distribution of functions within the building.[18] Therefore, the architect of a building would clearly benefit from integrating these various strategies, because they facilitate routes between important destination points. Results from empirical analytical systems, as summarized in this essay, should not be interpreted as a patent recipe for people-oriented architecture. Yet on the other hand, is it not an architect's responsibility while planning a building to consider the knowledge gained through empirical psychology about designing human behavioral space? Is it not possible to integrate a simulation of spatial behavior patterns in the form of a cognitive planning tool into an early phase of the architectural design process?[19]

These two interdisciplinary core issues will no doubt play a significant role in the future. Yet, while the first issue has occupied architects and psychologists since the beginnings of environmental psychology, two approaches

18 Mark D. Gross and Craig Zimring: "Predicting Wayfinding Behavior in Buildings. A Schema-based Approach," in: *Evaluating and Predicting Design Performance,* New York 1992, pp. 367–378.
19 It is worthwhile to predict dominant motion patterns beforehand, rather than to identify them after construction of the building is completed. This is certainly why the classic *Post-Occupancy Evaluation,* the goal of which was to assess and learn from existing architectural projects, did not prove as successful as sociologists would have hoped. See Wolfgang F. E. Preiser, Harvey Z. Rabinowitz and Edward T. White (eds.): *Post-Occupancy Evaluation,* New York 1988.

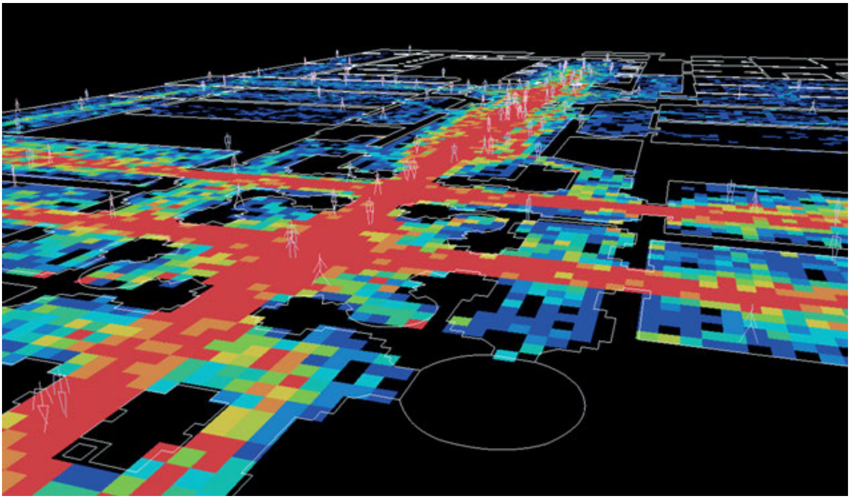


Fig. 5: Agent simulation of the Tate Gallery: The motion pattern of group behavior modeled by software agents and based on local visual references.

seem to be emerging with regard to the second issue, not least as a result of the ubiquitous dominance of digital technologies. They are: the use of virtual reality methods and the application of so-called agent systems.

For the most part, virtual reality methods are generally employed in architecture purely for visualization and presentation purposes, for example, during presentations for potential investors. By contrast, in the scientific field of empirical psychology, virtual reality models are employed as a helpful tool for cognitive psychological substantiation. Confronting test users with navigational tasks in virtual reality models can be useful during the design phase of an architectural project to establish whether a building design will lead to problems in navigation. The diagnostics, as pre-occupancy evaluation, offer a chance to recognize potential deficits at an early stage. Unlike virtual environments, which can simulate a realistic sense of space, agent systems simulate human behavior using a number of abstract software agents that move through a computer model of a building or an urban space [Fig. 5].[20] This method is already yielding significant successes in the field of architectural planning, although it is important to note that while such simulation systems provide data on the patterns of orientation behavior of large groups, they rarely contain any information about how an individual person perceives the design aspects of a spatial situation and why he or she decides on a certain course of action.

This is largely due to the fact that cognitive processes are mostly excluded – due to the limitations imposed by computer technology – and that the simulation therefore focuses exclusively on behavior as a direct product of visual perception. Herein lies an opportunity for the next generation of agent systems to re-examine cognitive psychological theories and studies in order to construct an agent model that takes into consideration the identifiable components of human decision-making, as well as the relevant spatial attributes.[21]

20 Thus, the agent model *Exosomatic Visual Architecture* (EVA) developed by British computer scientist Alasdair Turner is able to simulate the patterns of movement made by large groups of people and also make predictions.

21 Other important aspects besides perception processes and geometric modules include higher cognitive functions, such as learning mechanisms, semantic processing of objective information, a representation of the background knowledge of a building's attributes, and a plot for different navigational tasks. Creating a system such as this is the long-term goal of the Transregional Collaborative Research Center SFB/TR8 Spatial Cognition in Bremen and Freiburg.

Regardless of which of these approaches is chosen, one thing is indisputable: both the empirical and the cognitive theoretical approach are productive scientific instruments while gaining knowledge about human perception and patterns of spatial behavior. When architects integrate these instruments into the architectural design and planning process, they support the search for spatial solutions.[22]

22 Architects such as Gunter Henn are working on a methodical formalization of architectural programming in which cognitive theories can also be integrated. See, for example, Gunter Henn: "Programming – Projekte effizient und effektiv entwickeln" (Programming: Developing projects efficiently and effectively), in: *architektur: consulting,* Basel, Boston, Berlin 2004, pp. 42–49.

Markus Christen

PATTERNS IN THE BRAIN
NEUROSCIENTIFIC NOTES ON THE PATTERN CONCEPT

Patterns are regular configurations of different components. Taking this definition as the point of departure in the search for pattern leaves much room for interpretation, and undoubtedly calls for a more precise and detailed definition depending on the specific field of application. Yet even such a detailed definition merely opens another window onto far-reaching questions that, in turn, characterize the respective chosen scientific field. This conclusion does not point to the rather trivial assertion that (empirical) science seeks to identify patterns in the world and tries to explain their existence and specific characteristics – in other words, that there is a direct association between the concept "pattern" and the general objective of the enterprise known as science. It is far more significant that the terms "regular," "configuration," "different," and "components" each represent a specific collection of questions, the answers to which provide much insight into the objectives and methodology of the relevant discipline. The same is true for neuroscience. This essay will therefore dissect, as it were, the pattern concept from a neuroscientific perspective. The aim is twofold: firstly, to present some of the fundamental questions that confront neuroscience today, and secondly, to shed more light on the concept of pattern by means of this analysis.

"Pattern" as a Blanket Term

Science begins with the (at times naïve) recognition of patterns in the world that lead to further questions. This fundamental idea can be traced to a variety of authors – one interesting variant was published by the economist Friedrich August von Hayek in his work, *The Theory of Complex Phenomena,* completed in 1961.[1] In this treatise, von Hayek explains that a theoretical notion of pattern is always necessary in order to classify the specific phenomena that comprise the potential objects of a scientific theory. The goal of such a theory is to define a category of patterns whose individual occurrence is tested in the real world.

1 Friedrich August von Hayek: *The Theory of Complex Phenomena* (1961), Tübingen 1972.

Pattern identification then becomes pattern recognition. This fundamental conclusion is notably present in a number of examples in neuroscience. We will examine some of these below.

However, before going deeper into the variety of contexts in which one may search for neuronal patterns, we will begin by looking at the general definition of the term "pattern." Although undoubtedly logical, the demand for "regularity" – the first component of the definition – should not lull us into subscribing to the idea that patterns are no more than the mere repetition of structures or events. The regular character of configurations can be expressed in a variety of ways; indeed, establishing the specific law that describes this regularity is in itself one of the core objectives of the scientific undertaking when studying patterns. When a system is subjected to an experiment, the search for regularity constitutes a methodical program. In stimulus-response experiments – a basic experimental paradigm in neuroscience – stimuli are repeatedly applied to a system in order to derive conclusions from this process concernig the uniformities within the internal mechanism of the stimuli-processing apparatus. Expressed abstractly, the law by which the system reacts to stimuli can be conveyed in repetitions (regularities) or periodicities, mathematical sequences, or even complex mathematical equations. The established law does not necessarily have to be simple in form.

The term "configuration" implies that – before we even embark on the search for a pattern – we must already have an idea of the framework within which the elements that form the potential pattern reside. Space and time are obvious choices for foundational categories. Accordingly, physical entities are configured in space or events are arranged along a time axis. Hybrid forms, that is, spatiotemporal patterns, are of course also possible and – as will be clarified further below – are of particular interest in the field of neuroscience. Once again, we should guard against oversimplification. The mathematical analysis of phenomena can lead us to a high-dimensional-state space in which the *true* patterns are hidden.[2] Visualizing such patterns poses a difficult problem for science and scientific theory.

2 In the dynamic systems theory, reconstructing state spaces from time series, otherwise known as *coordinate delay construction,* is a standard procedure. This reconstruction allows a state space to be divided up to a certain degree and the dynamics of a system to be encoded in a sequence of symbols. One can search for patterns in these sequences. See: Holger Kantz, Thomas Schreiber: *Nonlinear Time Series Analysis,* Cambridge 2000.

The adjective "different" points to yet another problem: making differentiations is equivalent to categorizing a universe of discourse – and categorizations are by no means trivial. There are two different, basic aspects here: categorizations can emerge as a consequence of preconceptions (top down) or as a result of local interaction (bottom up). These distinct methods lead to two different basic systems of the search for patterns, called pattern recognition and pattern discovery.[3] At the same time, this distinction makes Hayek's basic idea somewhat questionable, because he seems to have omitted the aspect of pattern discovery. One possible approach is to distinguish between explicit theoretical specifications (the pattern demanded by the theory that is to be matched) and implicit factors influenced by the discovery procedure. This will be addressed at the conclusion.

Lastly, the term "component" points to a final fundamental issue in the pattern concept. The entities in a world that has been shaped by the evolution dynamics have a hierarchical structure[4] – and thus the choice of level within the hierarchy defines the field of science that is to be examined either in part or as a whole (the pattern). The choice of hierarchy level and the type of categorization can only be separated with great difficulty. Neuroscience – whose basic task it is to "explain behavior in terms of the activities of the brain" – is particularly affected by this problem, even more so because distinctly different types of patterns that exist on various levels have to be compared and related.

To recapitulate, this short introduction demonstrates that "pattern" is an overarching term representing four scientific and theoretical complexes of questions. When we focus on pattern theory, questions arise with regard to a specific framework and levels of hierarchy in which patterns are matched, or with regard to the categories that form the basis of the search for patterns and that determine their laws.

3 For more on this difference see: Cosma R. Shalizi and Jim Crutchfield: "Computational Mechanics: Pattern and Prediction, Structure and Simplicity," in: *Journal of Statistical Physics,* 104(3/4), 2001, pp. 817–879.

4 This theory is excellently developed by Herbert A. Simon: "The Architecture of Complexity," in: *Proceedings of the American Philosophical Society,* 106(6), 1962, pp. 467–482.

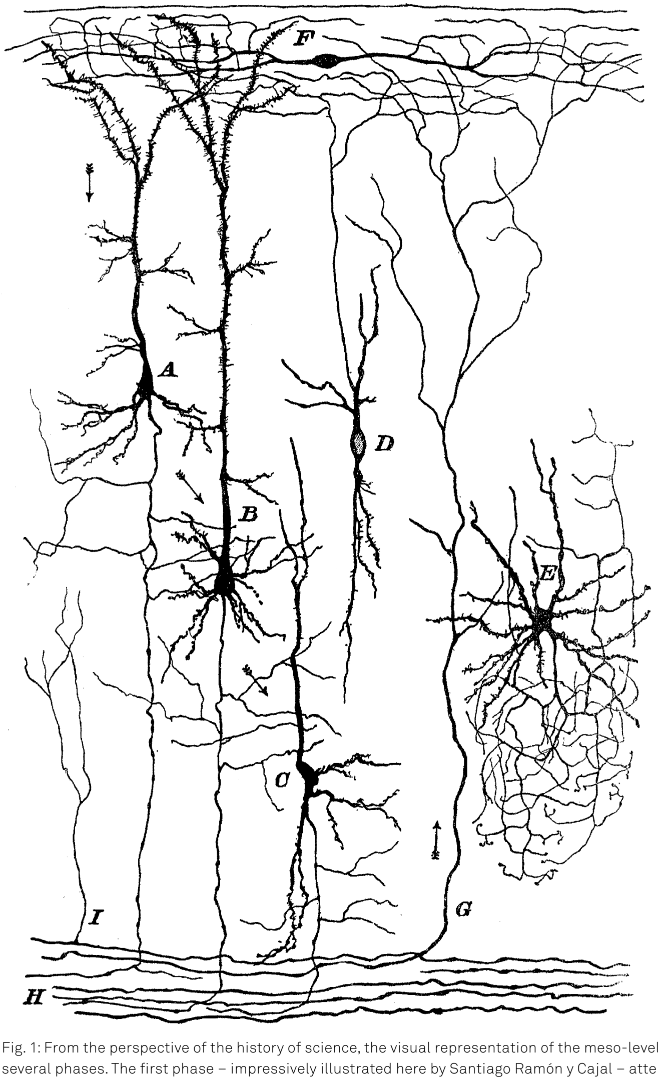


Fig. 1: From the perspective of the history of science, the visual representation of the meso-level of neuronal structures has several phases. The first phase – impressively illustrated here by Santiago Ramón y Cajal – attempts to present the most true-to-detail illustration of the morphology, which admittedly is the result of a selection process that includes both the act of staining cells and drawing specific cells.

Neuronal Patterns as a Field of Research

This essay can only focus on a small section of the impressive scope of problems that go along with the concept "pattern." But first we should recall the complexity of problems involved in the field of neuroscience in a short overview of the potential types of neuronal patterns. The spatial dimension contains everything from molecules to large organisms of all objects of the neuronal focus of interest – one moves between seven large scales.[5] At the molecular level, the question of pattern concentrates, for example, on searching out typical configurations of ionic channels on the cell membrane of neurons. However, if the neurons themselves are the focus of study, the focus shifts to the characteristic shapes or uniformities in the interconnecting structure. At the brain level, the main focus is gradually shifting towards examining how certain regions of the brain are connected (for example when comparing brains of biological species). We do not need to go any deeper into the impressive amount of knowledge that has been gathered on these different questions. It suffices to say that the largest gaps in knowledge are currently pertaining to the level of neuronal connections, more specifically, whether there are reproducible patterns of neural connections according to different regions of the brain. One speaks of the meso-level here as well, operating on a scale of several hundred micrometers [Fig. 1]. We are already aware of the existence of certain regions, such as the cerebellum or the hippocampus (another region that is essential for the memory process), where neuronal connections follow strict patterns. Yet it is still hotly debated as to whether this also applies to the cortex, the area of the brain that is the most essential biological infrastructure for the human intellect. The idea of a pattern becomes a hypothesis of an established interconnection of basic types of neurons that repeat regularly: the idea of a microcircuit.[6] This hypothesis touches upon Herbert Simon's theory, which is mentioned above (see page 73). His theory asserts that a system rooted in evolution cannot design itself from scratch, but rather replicates a pre-existing pattern – in the case of the cortex, a basic pattern such as this would be repeated a million times.

5 Patricia S. Churchland, Terrence J. Sejnowski: *The Computational Brain,* Cambridge 1992, p. 11.

6 See here: Rodney J. Douglas, Kevan A.C. Martin: "Neuronal circuits of the neocortex," in: *Annual Review of Neuroscience,* 27, 2004, pp. 419–451.

Neuroscientists clearly agree that focusing on the space framework alone is not sufficient for the objectives of neuroscientific research – behavior also unfolds with time. Accordingly, the temporal patterning of events has to be considered a core aspect. Events such as these can be found on different time scales; they are, however, more difficult to individualize. This problem is most obvious at the level of behavior itself. The issue of behavioral patterns calls for a sequencing of behavior into individual components. For example, one claim might be that behavioral patterns are composed of a repetition of certain sequences of such components.[7] The problem of classification that arises here – one dimension of the pattern concept – will be explained using the example of "neuronal impulse" (spike).

Connecting the spatial perspective with the temporal reveals the true complexity of the pattern concept when applied to neuroscience. A sensory stimulus in the course of neuronal processing could become an entire set of sequences of neuronal impulses that spread along various spatial channels, which brings us to spatiotemporal patterns. However, here we see that a precise definition of the term spatiotemporal pattern, which is common in neuroscientific publications, raises difficult methodological and statistical questions.[8] For example, spatiotemporal patterns influence and change the functionality of neuronal connections over a long period of time – and thus the future appearance and form of the pattern also changes. Furthermore, the term "pattern" often simply means "something is there" that, in the relevant experimental context, presents the neuronal answer to an experimental stimulus.

The methodological challenges involved at this meso-level are enormous. Even small regions of the brain, such as the rat's olfactory bulb, are comprised of many thousand cells, of which only a dozen at most can be measured. Strictly speaking, this is the only way we can examine the detailed mechanics of neuronal information processing.

7 Studies done on the behavioral sequences in the courtship behavior of the fruit fly offer an informative analysis. See: Ruedi Stoop, Benjamin I. Arthur: "Periodic Orbit Analysis Demonstrates Genetic Constraints, Variability, and Switching in Drosophila Courtship Behavior," in: *Chaos,* 18(2), 2008, 023123.

8 For more extensive theories on this subject see: Markus Christen: *The Role of Spike Patterns in Neuronal Information Processing. A Historically Embedded Conceptual Clarification.* ETH-Dissertation No. 16464, 2006.

Hence, imaging methods[9] that operate on a larger spatial scale compared to a detailed analysis of local neuronal network – in other words on a scale of millimeters – are very fascinating. Yet it must be first mentioned that the cognitive and social neurosciences rely heavily on functional magnetic resonance tomography (fMRT) – a method that measures oxygen consumption in certain regions in the brain (the image resolution is at the moment approximately one cubic millimeter). The oxygen consumption indicates neuronal activity, yet there are still many unanswered questions concerning the nature of signals gathered by the fMRT scanner.[10] Yet the imaging of these measurements is exactly where we see the core problem of unreliable simplification – critics even speak of a "new phrenology"[11] or, in other words, a hasty correlation of cerebral regions with complex psychological entities. The method itself does not lead to this simplicity and, in the near future, it will allow the integration of temporal components (meaning, for example, the detection of sequences of individual activated regions of the brain). Imaging, however, may present neuroscientific knowledge in an overly simplified manner that does not correspond to the complexity of the underlying phenomenon. This shortcoming signifies a need for closer examination, which was at the outset only carried out on a rudimentary basis.[12]

The Search for Patterns Using the Example of Neuronal Codes

We will now shift our focus to the four basic problems of the pattern concept that were described above as "regular," "configuration," "difference," and "components." We have already examined the question of the different levels of pattern occurrence and the question concerning the relevant framework; now we will turn our attention to the issue of categorization. The problem of deter-

9 Imaging is the neuroscientific procedure that can collect and illustrate structures in the nervous system or activities of entire groups of nerve cells. For an introduction into the individual procedures see: Lutz Jänke: *Methoden der Bildgebung in der Psychologie und den kognitiven Neurowissenschaften* (Methods of imaging in psychology and cognitive science), Stuttgart 2005.

10 For a comprehensive overview of these open questions see: Nikos K. Logothetis: "What We Can Do and Cannot Do with fMRI," in: *Nature,* 453, 2008, pp. 869–878.

11 A perfect example here is William R. Uttal: *The New Phrenology. The Limits of Localizing Cognitive Processes in the Brain,* Cambridge 2001.

12 See, for example, Joseph Dumit: *Picturing Personhood. Brain Scans and Biomedical Identity,* Princeton, Oxford 2004.

mining regularity, however, exemplified as the far-reaching question of whether human behavior derives from certain given neuronal patterns, will not be addressed here. This question ultimately leads to the debate about free will and, thus, to the ideological dimension of the pattern discourse, because patterns can also mean prototype. Neglecting individual variance (which is not insignificant in brain activation patterns, detected by fMRT methods correlated with behavior) could mean that, someday, a typical activation pattern that can be read in children's brains might be proclaimed for social abnormality, giving reason to take appropriate measures. But we cannot concern ourselves here with the ethical consequences of forensic neuroimaging.[13]

The following explanations will deal mainly with the temporal framework and discuss the impact made by the neuronal pattern theory on the context of the neuronal code debate. This happened in two phases: firstly, one has to understand how the "component" of the pattern, meaning the neuronal impulse or spike, is procured. On this basis, a theoretical framework – here, information theory[14] – would be chosen, so that the role of these spike patterns, as elements of a code, could be defined at all. And, since subsequent scientific efforts proved that this coding-approach of "pattern recognition" was doomed to fail, it is useful for identifying factual problems when searching for patterns in the domain of neuroscience.

At the beginning of the twentieth century, the electrical activity of nerve cells were described in the scientific literature with terms such as "nerve energy" or "action currents." Science at the time did not yet posses the appropriate measuring equipment to precisely examine these activities. The string galvanometer first made it possible to more accurately measure and (by using photo plates) record neuronal activity. With the availability of electronic valves, amplifiers could be constructed that clearly improved the resolution of the analysis of the phenomenon. This, in combination with an oscilloscope, enabled several research groups at the beginning of the 1920s to visualize "nerve energy" as an actual impulse. This visualized, clearly manifested result

13 See here Turhan Canli, Zenab Amin: "Neuroimaging of Emotion and Personality: Scientific Evidence and Ethical Considerations," in: *Brain and Cognition,* 50, 2002, pp. 414–431.

14 On the information theory and the introduction of the information concept in the natural sciences, see: William Aspray: "The scientific conceptualization of Information: A Survey," in: *Annals of the History of Computing,* 7(2), 1985, pp. 117–140.

made it possible to scientifically examine the relationship between the nerve impulse and its significance. The crucial figure here was the British physiologist, Edgar Adrian (1889–1977). In numerous experiments in the 1920s, he measured electrical activity in the sensorial nerve cells of a frog, in order to determine the relationship between stimulus intensity and the neuronal activity it triggered.[15] Adrian introduced the concept of message and information in relation to the neuronal activity gathered by measurement technology.[16]

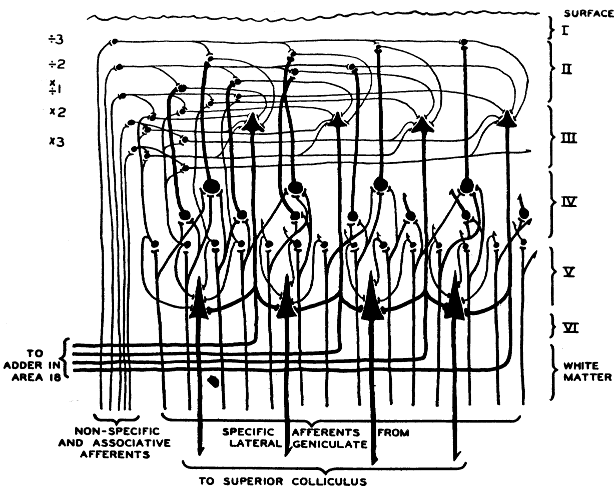
A glance at Adrian's methods reveals that the relationship between information and the measured sequences of impulses was by no means a simple act of observation. Adrian had to establish that all of the impulses he measured belonged to the same message. The placement of the electrode was too imprecise to guarantee that only one nerve fiber had in fact been measured. Therefore, Adrian assumed that individual nerve cells fired at regular intervals – in other words, displaying a clearly recognizable pattern – and, accordingly that ascertaining a periodic pattern must in fact be the result of a message having been sent by one single nerve cell. Theoretical presumptions of this sort, which serve to establish a scientific object of research, are not surprising and are not rendered obsolete after measurement equipment has been perfected.

These studies from the 1920s and 1930s formed the basis for an information-theoretical vocabulary that was developed further by neuroscientists in the 1940s. Nerve cells were understood as channels and digital (in other words clearly distinguishable) spikes as the possible components of a code. The question of the neuronal code was raised – directly or indirectly – whenever the information-theoretical vocabulary was applied to the nervous system. The term "code" first appeared in context with the emergence of cybernetics. John von Neumann explicitly used this elaborated concept at the Macy Conference in 1950 – albeit with skeptical undertones.[17] Other Macy Conference participants also spoke of the rather "obscure character" (Gregory Bateson) of using the concept of a "code" in relation to the nervous system.

15 A summary of his work can be found in: Edgar A. Adrian: *The Basis of Sensation,* London 1928.

16 Justin Garson: "The introduction of information into neurophysiology," in: *Philosophy of Science,* 70, 2003, pp. 926–936.

17 Heinz von Foerster, Margaret Mead, Hans L. Teuber (eds.): *Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems, Transactions of the Seventh Conference (March 23–24, 1950).* New York. Republished in Claus Pias, *Cybernetics | Kybernetik. The Macy-Conferences 1946–1953,* Zurich, Berlin 2003.



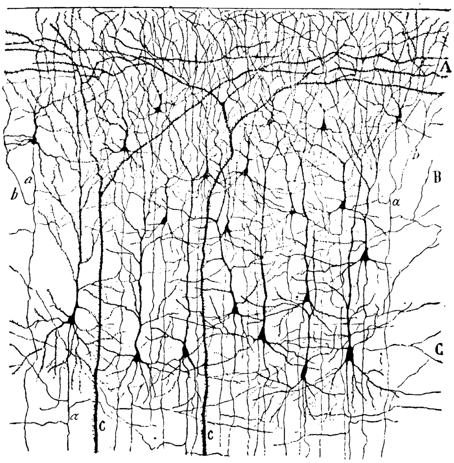


Fig. 2: In another phase, the biological model only serves as a (vague) illustration of a speculative idea of the brain's function. The pattern of neuronal circuits is depicted in a much more ordered manner, as seen here in Walter Pitts and Warren McCulloch's renowned publication. This illustration is typical of the cybernetic view of the brain, where representations of the biological brain are superceded by "diagrammatic" illustrations, as Michael Hagner expounded ("Bilder der Kybernetik: Diagramm und Anthropologie, Schaltung und Nervensystem" [Images of Cybernetics: diagram and anthropology, circuits, and nervous system], in: Michael Hagner, *Der Geist bei der Arbeit* [The mind at work], Göttingen 2006, pp. 195–222).

Nonetheless, the topic awakened the interest of neurophysiologists as well as cyberneticists[18] [Fig. 2]. In the process, it appeared that the term "code" had been used for different forms of neuronal information processing since the very beginning. In the 1950s, there were four versions for such codes,[19] two of these (suggestions by Warren McCulloch[20] and Anatol Rapoport[21]) having accrued from purely theoretical considerations. Other versions that developed throughout the 1960s were also established on a theoretical basis. One example is the concept known as the pattern code, which Rapoport referred to in 1962 at a conference in Leiden, where the issue of neuronal information processing was widely discussed. "This idea [a pattern code] is very attractive to those who would think of the operation of the nervous system in the language of digital computers, because a fixed temporal pattern, although in principle subject to a continuous deformation, has a strong resemblance to a digital code. It is in fact a generalization of the Morse code. It is also like a template of a key. The discovery of such patterns would immediately pose a challenging decoding problem."[22]

The scientific conceptualization of information in neuroscience was in full swing at this time, and the search for more codes – such as the idea of the pattern code in which regular, complex patterns of impulses formed what could be understood as messages – occupied several established neuroscientists.[23] The search for a neuronal code reached its climax at the end of the 1960s when the researchers who were most active in this field met in 1968 for a

18 See here the detailed discussion in Christen, 2006, chapter 3.

19 Called "labeled line code" (the coding occurs through the nerve impulses traveling through different nerve fibers), the frequency code (the number of impulses per time interval encodes the stimulus intensity, the model suggested by Adrian) as well as forms of timing codes; see the two ensuing footnotes.

20 P.D. Wall, J.Y. Lettvin, Warren McCulloch, Walter Pitts: "Factors Limiting the Maximum Impulse Transmitting Ability of an Afferent System of Nerve Fibres," in: C. Cherry (ed.): *Information Theory,* London 1956, pp. 329–344.

21 Anatol Rapoport, W. Horvath: "The Theoretical Channel Capacity of a Single Neuron as Determined by Various Coding Systems," in: *Information and Control,* 3, 1960, pp. 335–350.

22 Anatol Rapoport: "Information Processing in the Nervous System," in: *Information Processing in the Nervous System,* Amsterdam, New York 1964, pp. 16–23. Quote: pp. 21–22.

23 Such as Cornelius Wiersma, William Uttal, Theodore Bullock, P.D. Wall, and J. Segundo to name a few.

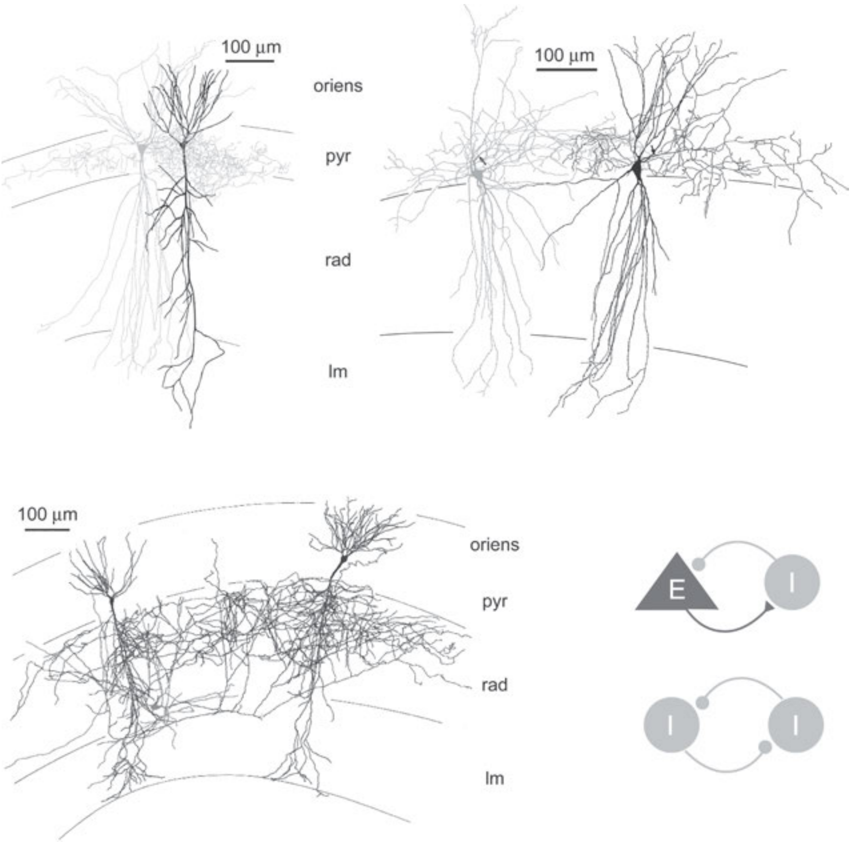


Fig. 3: Current work on the meso-level of neuronal structures, and associated theories regarding their functions, refer to today's technological possibilities that enable highly true-to-detail depictions of the biological model. Yet in the explanation or illustration of the functional relationships, the corresponding representations are often much simpler than in the cybernetic phase, and their function is to depict generalized principles of neuronal interaction (as seen above). Complex computer models and film presentations (that, for example, show the dynamics of how synapses are created) will gain significance in the future as a method of illustrating neuronal patterns on the meso-level, because the explanatory value of a cybernetic "diagram" has lost credibility.

Neurosciences Research Program work session.[24] The organizers opened the conference with the tongue-in-cheek question, "[I]s the code of the brain about to be broken?"[25] – in order to continue by saying that none of the participants believed that there was in fact a clearly defined neuronal code that could be broken. The publication read like a surrender to biological diversity. The elaborated concept of the code did not possess the desired unifying function, and the search for patterns as an element of such a code proved misguided [Fig. 3].

Is It Possible to Discover Patterns?

This short history of the search for a neuronal code reveals the perils of the search for patterns in a complex system. An incorrect framework for pattern recognition would give researchers a warped perspective of the problem. But complications such as these are to be expected in a field of research such as neuroscience, where frameworks can restrict the levels of hierarchy as well as the categorization of the components that comprise a pattern. The question is whether they can be avoided. Is pattern discovery possible at all without first having to think about what to look for?

This methodologically significant question points to the general problem regarding the analysis of data gathered from complex systems, and also reaches beyond neuroscience. It should be elaborated here in somewhat more detail. The search for patterns can mean, on one hand, starting from a prototypical configuration of different components and counting how many times the configuration occurs. What needs to be solved is the problem of similarity or, in other words, what degree of affinity there should be in a real, found configuration in order to allocate this occurrence to the prototype. The search for patterns brings to mind the children's game where differently shaped blocks of wood have to be matched to holes on a board. This is an example of the top-down approach.

24 Donald H. Perkel, Theodore H. Bullock: "Neural Coding," in: *Neuroscience Research Progress Bulletin,* 6(3), 1968, pp. 221–348.
25 ibid, p. 225.

However, it is also possible to take an approach based on which scientific regularities the components follow when interacting locally, and then check the structures that emerge. The process of the search for patterns would thus be simulated in terms of a self-organizational process and the patterns that come forward would be surprising. New approaches in data analysis touch upon this idea of "unbiased classification."[26] They would help us to sidestep our theoretical preconceptions – perhaps even abandon them – and pave the way for true pattern discovery. After all, theoretical preconceptions are often very tempting but misleading to research, particularly in the field of neuroscience.

26 See, for example, Thomas Ott, Albert Kern, Willi-Hans Steeb, Ruedi Stoop: "Sequential Clustering: Tracking Down the Most Natural Clusters," in: *Journal of Statistical Mechanics: Theory and Experiment,* 2005, P 11014.

Isabel Mundry

REGULAR IRREGULAR – ON THE FLEETING QUALITY OF PATTERN IN CONTEMPORARY MUSIC

Why patterns? was the question Morton Feldman posed in 1978 with his homonymous composition for flute, piano, and percussion. The title of the work was almost superfluous, because the question it raises becomes evident as soon as one listens to the piece. The instruments create musical patterns with insistent continuity, yet question them again and again with the same insistence. The patterns are created by scales, figures, or sequences of sound that remain recognizable as single units in the configuration and can also be remembered as units when repeated. The sound patterns undergo fine variations, regroupings, secessions, or transformations; yet they are also stabilized by the same means. Their contours remain consistent but their individual character is fleeting. They are the medium that carries and supports the lingering and fading quality of this music: always endangered in their particular form, yet their contours remain resistant.

Morton Feldman was inspired by observing oriental carpets. He was fascinated by the play of elements that are joined to form larger units and then repeated in fine variations. On one hand the elements of the carpet are formalized by pattern formation, yet manual workmanship lends them individual character. The symmetry in these designs sharpens the senses for distinctive qualities, while always leading back to the pattern from which subsequent distinctive qualities are re-emphasized. Hence, studying ornamentation in an oriental carpet is in effect an encounter with fleeting contours in the course of time. It is most certainly a musical perception without sound, a perception that, in turn, comes closer to the actual acoustic impression of Feldman's music [Fig. 1].

Morton Feldman re-examined the significance of patterns with his composition, yet two decades earlier this concern was categorically rejected by relevant positions of contemporary music. Neither the serial nor the aleatoric compositions of the 1950s endeavored to use small units to construct large ones, which would then be repeated. This created internal musical hierarchies, yet the concern of music at that time was to achieve a maximal level of entropy by distributing elements in order to prevent emphasis. The reasons behind this

Fig. 1: Morton Feldman, Detail from: *Why Patterns?* Composition for flute, piano and percussion, 1978.

can be found in the evolution of music history: music managed to gradually free itself from the tonal system, which can be described as pattern formation. Within the series of twelve halftone steps, the major and minor scales form a seven-tone scale of whole tones and semitones. This gives the scale a distinguishing character. The key is established by a cadence pattern of three sequential chords that links the particular notes of a scale. Even though the keys are transportable and there are twenty-four versions altogether, the pattern of both seven-tone scales remains absolutely stable. All tonal music can be traced back to these two types and all musical imagination is articulated in them, even if there are subjective sound languages. The tonality of Johann Sebastian Bach's music is formed differently than that of Franz Schubert. This can be described and justified in technical terms. Yet it is precisely this range of diversity that confirms the system. Nevertheless, a process of expansion emerged that freed this system from restrictions: secondary notes and chromatic variations were added to the cadences, the leading tones became independent, and the modulations undulated further and further away until they increasingly lost their center. Thus, cadence harmonics gradually became elliptic harmonics. Arnold Schönberg applied the results of this development by deriving new rules from the condition of lost tonality and creating the twelve-tone technique. This prevented any emphasis on a seven-tone scale within the framework of a twelve-tone chromatic totality. The twelve-tone technique may well be an ordered system, but it is not a pattern, because it always gathers and exhausts the possible total. The composers of the Second Viennese School (Schönberg, Berg, and Webern) reacted very early to this by subdividing the twelve-tone rows into symmetric sections. This exhausted the chromatic totals, yet divided them into smaller sections that created gradations between the entropic diversity and the emphasized configurations. Nevertheless, for the time being, music history continued along the path of freeing music from prescribed limitations. Serialism conveyed the principle of series formation to all other parameters, such as volume, tone, and so on. The basic rule was that nothing could be repeated until all possibilities had been exhausted. Universes were to be developed without emphasis or hierarchies. Aleatoric compositions had similar aspirations, but the method they applied was chance rather than calculation. Yet our perception makes us think we see patterns where patterns were not intended, which is what happens when we gaze into a night sky full of stars. It creates gra-

Fig. 2: Isabel Mundry, detail from: *no one,* composition for string quartet, 1994/95, Breitkopf & Härtel, Wiesbaden, Leipzig, Paris, Kammermusik-Bibliothek 2456.

dations between contours and voids or gets caught up in the memory of familiar notes while ignoring other notes. The technical development of composing may have had good reason to develop serial and aleatoric entropies, but the experience of listening puts it all back into perspective.

no one, the title of a string quartet I composed in 1994–95, was my response to the impressions of Feldman's music. Feldman preserves a distance to his elements, allowing them to float past like fish behind glass. Yet I wanted my composition to advance in various degrees. This difference has consequences for the position of pattern formation itself. Feldman equates his compositions with patterns. One sequence of notes calmly follows the next; they are always subject to variations without ever really influencing one another. With my music, I had the opposite in mind. The smallest unit in my music was to be the signature and not the formula, that is, gestures of subjective expression that put each other into perspective and that intensify, complement, or weaken one another [Fig. 2]. In order to allow for this reciprocity and not allow the gestures to float alone in space, the music needed a structure on a different level. Consequently, the pattern formation is created not by single units; it is created by calculating possibilities that have a precisely designed chain-like course, but a content that cannot be anticipated. I use the image of a tourist group to help visualize this process: all the members of the group start out on a trip from A to B at the same time, but the route and the timing are not predetermined. Hence they will all cross the same river but will use different bridges at different times. A mountain chain will be crossed from one side or the other; individuals will either rush past a village or linger for a while. In order to design these processes musically, I developed the composition on three levels: the first level can be compared with a meandering landscape. I then created basic conditions based on flowing processes: the music becomes successively deeper in tone, its range broader, the dynamics more restrained, and the articulation passes through different fields of characteristic variations, such as *tremolos* or *glissandi.* On the second level, I organized the units of time for the travel routes. Each route can be compared with the voice of an instrument, and the action of either lingering or rushing by is individually designed for each instrument. For that reason, I gave them distinct rhythms and dispensed with the usual vertical organization. In this quartet the rhythm marks each section within the melodic course of a voice. It behaves like a microcomposition of the whole. The cycles fluctu-

Fig. 3: Shoowa, embroidery and velvet, 59 x 56.5 cm.

ate, which, together with the interplay of instruments, creates blurred areas with an arrangement that changes from performance to performance. The third level effects the melodic configurations within the rhythm. There is a system of rules here that might be compared with old melody and rhythm lessons. Hence, for example, every rhythm is subject to a chord played in succession, whose tones are given an open sequence but always start with the highest and finish with the lowest. Thus, in the first few minutes, the general descending movement is reflected on this microlevel. In line with the specified rules, this level is influenced by signature individual decisions. The first level provides the landscape, the second sets the rhythm of the journey, and the third is the experiential level that proceeds differently from instrument to instrument and from rhythm to rhythm.

This composition was also influenced by textile patterns. I immediately got ideas relating to music the first time I saw patterns created by the Bakuba African tribe. Unlike the structures of oriental carpets, these textiles have interweaving repetitions of contours and large transformations. The pattern units are created by complex interlaced elements, such as diamond forms, that are composed of a sum of lines and small squares. Repeating the units gradually changes their elements, and the contours also change until a new pattern defines the impression. Here, pattern formation is a medium of change [Fig. 3 and 4].

I had similar processes in mind while I was composing the string quartet. Conceptually establishing three levels – note progression, units of time, and gesture – allowed me to create a form of flowing change, from which each individual element could emerge as a uniquely formed moment. Yet it prevented the three levels crossing one another too dramatically and, for example, prevented one gesture from tipping the entire form, or prevented the landscape being empty of travelers for too long. The relationship between regularity and irregularity had to be a thematic focus, in order to arrive at such moments of experience.

Feldman and I are not the only ones who have studied patterns. There has been an interest in this area for a while. Following the serial and aleatorical works that produced a maximal level of heterogeneity – and the subsequent period of virtual silence in view of excessively aesthetic taboos – diverse approaches in new music began to develop, focusing on opening new degrees

Fig. 4: Shoowa, embroidery and velvet, 45 x 45 cm.

of freedom without digressing to traditional tonal languages. Many of these approaches concentrated on formalizing individual levels in order to discover innovative forms of expression on other levels. Spectral music, for example, developed a new system of harmonics that was organized according to the physical laws of semitones. The tone here does not remain an isolated figure; each one is integrated into a tonal palette that enhances and surrounds it. Consequently, the tone creates a pattern of which it first becomes an element itself, and which, in turn, also generates the entire tonal design. This allows the music to develop a "basic color," which supports and homogenizes all the subsequent distinctive qualities and contrasts.

In contrast, compositions that are organized using a fractal structure concentrate on time-based pattern formations. Based on an algorithmic system of rules, they organize a variable logic of successive tonal experiences that propagate like cells. This can lead to rampant processes but can always be traced back to a constant pattern, like all fractal structures. Since this model includes recursive progressions, characteristic constellations are created that can be heard again and again. All in all, this music simulates organic processes, yet still remains abstract inasmuch as the individual tonal experiences are reduced to the function of a cell within the time-based system of rules.

Despite the differences, Feldman's composition *Why Patterns?,* spectral or fractal music, and my string quartet are all musical positions connected by a passion to generate patterns and to allow the unpredictable. To achieve this, they effect a categorical distribution that establishes the relationship between the stable and the instable. Yet the uncertainty established by these means proves to be a contradiction. By referring to its restrictions, it threatens to freeze into a pattern itself.

As soon as my response to this observation and experience resulted in maximal disorder, I put all of my sketches away and began composing pieces about which I had only an atmospheric notion. Yet, even the music this approach created resulted in structures as soon as it took shape. It frames the notes in tonal pitches and chords and gives time a form from which smaller units crystallize. These works automatically created just what they set out to prevent, namely stable patterns, even though they were created from a series of unconscious preferences rather than calculation.

Fig. 5: Isabel Mundry, excerpt from: *Ich und Du,* composition for piano and orchestra, 2008.

Why patterns, if they ultimately just constrict when they are supposed to open and, when unwanted, even self-propagate? Considering the inevitability of patterns, this seems to be the wrong question. Yet the question takes on a different meaning as soon as the issue of "why" becomes an issue of the relations of the patterns, or of their location and aesthetic meaning.

In the composition *Ich und Du,* which I wrote in 2008 for piano and orchestra, pattern formations and their significance are explored inner-musically again and again. Given the arrangement of a solo instrument and orchestra, one might assume that the prescribed roles are stable – yet in this composition they are constantly subject to change. Inasmuch as *Ich und Du* signify musical principles, freed from the fact of whether they are represented by one or many instruments, they also signify the counterpoints of two perspectives. *Ich* is the place of central perception and *Du* the place of projection. Both principles are in constant movement in this composition. It deals with regroupings, reinterpretations, demarcations, assaults, and ascriptions, controlled internally or externally. All of these conditions are articulated in time, solidify or become fluid. For this reason, pattern formations, their transformations, solutions, or regroupings are genuine time-based phenomena in this music, which makes it different from the above examples [Fig. 5]. The difference can be found in the architectural conception of the work. In music, the concept of architecture can be compared to the relationship between large arrangements and subdivisions that behave like rooms in a building. Traditionally, it has described form by describing the relationship between a large form and its parts. Hence, the architecture of the classical sonata main form consists of the succession of exposition, development, reprise, and coda. Yet there have always been form types that are liable to different thought models. Beyond the traditional definition, the concept of architecture in a music context has become volatized or individualized. In my compositions, it plays a supportive role when I situate it within the relationship between the place of central perception and the space that enables and surrounds it. When metaphorically composed in this manner, it can be applied to music on many levels. It can, for example, describe the relationship between a particular tonal space and its inner configurations, or the relationship between an articulated tonal moment and its time-based peripheries. And it can always be developed in two directions: from architectural placement to the perception level or viceversa. I would describe perception as the place of the sensorial alignment of the musical imagination. It is a structural experience that originates from different structural arrangements and also implicates these as well.

In the quartet *no one,* the relationships between the architectural framework and the sensorial individual decisions were set up vertically, while the rhythms build the patterns, and their content is responsible for the inevitable. Despite the organic form of the music, this relationship always remains static, which makes the function of the pattern also remain static. On the other hand, in the piano concerto *Ich und Du,* I intended a succession of pattern formations and releases, in that both positions were mutually reflected and reciprocally influential. This creates a constellation of changing architecture. An example can be found in the middle section of the piece: the piano's note expansions are conducted in several approaches. These start either with individual piano tones that that are initially alone, but then followed by other instrumental sounds. Consequently, imaginary pianos grow from the one original piano, which create structures, which then become patterns by repeating some of their elements in various ways. Yet these patterns are arranged so that they can be enhanced by other elements, by which means they increasingly lose their contours. The music thus becomes more and more vast until the piano eventually emerges as a solo element again, creating new figurations, new patterns, new transformations, and new releases.

Patterns can be a place of experience, and not rigidity, if they are allowed to change along with the time that surrounds them: the relationship between the stable and the instable can always be re-examined and reconstituted.

SELECTED LITERATURE

This selected bibliography lists the texts referred to by the authors of this volume. It has also been supplemented by relevant texts. Entries are ordered chronologically. Where feasible and useful, dates of first or original editions have been cited.

—

Owen Jones: *The Grammar of Ornament, illustrated by examples from various styles of ornament, one hundred folio plates, drawn on stone by F. Bedeford,* London 1856.

—

Adolf Loos: *Ornament und Verbrechen,* 1908; see also *Ornament und Verbrechen: ausgewählte Schriften: die Originaltexte,* Vienna 2000. (See also Adolf Loos: *Spoken into the Void: Collected Essays,* transl. by Jane O. Newman and John H. Smith, Cambridge 1982.)

—

Karl Blossfeld: *Urformen der Kunst,* Berlin 1928.

—

László Moholy-Nagy: *von material zu architektur,* in: Bauhausbücher, Vol. 14, 1929, reprint Mainz 1968.

—

Karl Blossfeld: *Urformen der Kunst. Wundergarten der Natur,* 1928–1932, Berlin 1932.

—

Edward C. Tolman: “Cognitive Maps in Rats and Men,” in: *Psychological Review,* 55(4), pp. 189–208, 1948.

—

Max Frisch: *Tagebuch 1946–1949,* Frankfurt am Main 1950 (1971).

—

Heinz von Foerster, Margaret Mead, Hans L. Teuber (eds.): *Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems, Transactions of the Seventh Conference,* New York 1950. Republished in Claus Pias: *Cybernetics/Kybernetik. The Macy Conferences 1946–1953, vol. II,* Zurich, Berlin 2003.

—

James J. Gibson: *The Perception of the Visual World,* Boston 1950. in: id.: *The Ecological Approach to Visual Perception,* Boston 1979.

—

P. D. Wall, J.Y. Lettvin, Warren McCulloch, Walter Pitts: “Factors limiting the maximum impulse transmitting ability of an afferent system of nerve fibres,” in: E. C. Cherry (ed.): *Information Theory,* London 1955, pp. 329–344.

—

Noam Chomsky: *Syntactic Structures*, The Hague 1957.

—

Kevin Lynch: *The Image of the City,* Cambridge, Mass. 1960.

—

Herbert A. Simon: “The Architecture of Complexity,” in: *Proceedings of the American Philosophical Society* 106(6), 1962, pp. 467–482.

—

Serge Chermayeff und Christopher Alexander: *Community and Privacy: Toward a New Architecture of Humanism,* New York 1963.

—

Friedrich August von Hayek: *The Theory of Complex Phenomena.* Tübingen 1972. Originally published in: M. Bunge (ed.): *The Critical Approach to Science and Philosophy,* New York 1964.

—

Louis Sullivan (ed.): *A system of architectural ornament: according with a philosophy of man’s powers,* New York 1924; facsimile, Park Forest, Ill. 1964.

—

William A. Vetter: *Computer Graphics in Communication,* New York 1964.

—

Christopher Alexander: *Notes on the Synthesis of Form,* Cambridge, Mass. 1964.

—

Christopher Alexander: “The Question of Computer in Design,” in: *Landscape,* Vol. 14, Vol. 3, 1965, pp. 6–8.

—

Christian Norberg-Schulz: “Architekturornament,” in: Mark Buchmann (ed.): *Ornament ohne Ornament,* exhibition catalog in five brochures, Zurich 1965.

—

Max Bill: “Sinn ohne Sinn?,” in: *Zürcher Woche,* Vol. 29, July 16, 1965, p. 13.

—

Christopher Alexander: “The Pattern of Streets,” in: *Journal of the AIP,* Vol. 32, Vol. 5, September 1966, pp. 273–278.

—

Christopher Alexander: “From a Set of Forces to a Form,” in: György Kepes (ed.): *The Man Made Object. Vision and Value Series,* Vol. 4, New York 1966, pp. 96–107.

—

Christopher Alexander, Van Maren King, Sara Ishakawa, Michael Baker, Patrick Hyslop: “Relational Complexes in Architecture,” in: *Architectural Record,* September 1966, pp. 185–189.

—

Theodor W. Adorno: *Funktionalismus heute,* lecture at the Deutschen Werkbundes Conference, Berlin, October 23, 1965; published in: *Neue Rundschau,* 77. Vol. 4. Issue 1966.

—

Marshall McLuhan: *The Medium is the Massage. An Inventory of Effects,* New York 1967.

—

Donald H. Perkel, Theodore H. Bullock: “Neural Coding,” in: *Neuroscience Research Progress Bulletin* 6(3), 1968, pp. 221–348.

—

Heide Berndt, Alfred Lorenzer, Klaus Horn: *Architektur als Ideologie,* Frankfurt 1968 (1979).

—

Christoph Feldtkeller, Dietrich Keil: “Alle mal pattern! Oder Zur Idiotiekritik. Anmerkungen zu Christopher Alexanders ‘Major Changes in environmental form required by social and psychological demands’,” *Arch+,* Vol. 8, October 1969, pp. 29–35.

—

Architectural Psychology: Proceedings of the Conference Held at Dalandhui, February 28–March 2, 1969, publ. by V. D.V. Canter, London 1970.

—

Hans Heinz Holz: “Die Repristination des Ornaments” (Revamping the ornament) in: *Vom Kunstwerk zur Ware,* Neuwied, Berlin 1972.

—

Christopher Alexander, Sara Ishikawa, Murray Silverstein, with Max Jacobson et al.: *A Pattern Language. Towns, Buildings, Construction,* New York 1977.

—

Hans-Georg Gadamer: *Die Aktualität des Schönen,* Stuttgart 1977.

—

Christopher Alexander, Sara Ishikawa, Murray Silverstein with Max Jacobson, Ingrid Fiksfahl-King, Shlomo Angel: *A Pattern Language. Towns, Buildings, Construction,* Cambridge 1977.

—

Michael Müller: *Die Verdrängung des Ornaments. Zum Verhältnis von Architektur und Lebenspraxis,* Frankfurt am Main 1977.

—

Ernst H. Gombrich: *The Sense of Order: A Study in the Psychology of Decorative Art,* Oxford 1979, The Wrightsman lecture, Vol. 9.

—

Lucius Burckhardt: "Design ist unsichtbar," in: *Design ist unsichtbar,* publ. by Helmuth Gsöllintner, Angela Hareiter, Laurids Ordner, Vienna 1980, pp. 13–21.

—

Jürgen Habermas: "Die Moderne – ein unvollendetes Projekt. Rede zur Verleihung des Adornopreises 1980," in: *Die Moderne – Ein unvollendetes Projekt. Philosophisch-politische Aufsätze,* Leipzig 1990.

—

Eric R. Kandel, James H. Schwartz, Thomas M. Jessell: *Principles of Neural Science,* New York 1981 (New York 2000).

—

Gerald Weisman: "Evaluating Architectural Legibility: Wayfinding in the Built Environment," *Environment and Behavior,* 13(2)/ 1981, pp. 189–204.

—

Christopher Alexander: "Kunst und Design für das 21. Jahrhundert," in: *Design ist unsichtbar,* publ. by Helmuth Gsöllintner, Angela Hareiter, Laurids Ordner, Vienna 1981, pp. 101–115.

—

"Contrasting Concepts of Harmony in Architecture," in: *Lotus International,* Vol. 40, 1983, pp. 60–68.

—

Stephen Grabow: *Christopher Alexander. The Search for a New Paradigm in Architecture,* Boston 1983, p. 55.

—

Romedi Passini: *Wayfinding in Architecture,* New York 1984.

—

William Aspray: “The Scientific Conceptualization of Information: A Survey,” in: *Annals of the History of Computing* 7(2), 1985, pp. 117–140.

—

Kent Beck, Ward Cunningham: *Using Pattern Languages for Object-Oriented Programs,* Technical Report No. CR-87-43, September 1987.

—

Sybille Krämer: *Symbolische Maschinen. Die Idee der Formalisierung in geschichtlichem Abriss,* Darmstadt 1988.

—

Donald A. Norman: *The Psychology of Everyday Things,* New York 1988.

—

Klaus Lepsky: *Ernst H. Gombrich, Theorie und Methode,* with a foreword by Ernst H. Gombrich, Vienna, Cologne 1991, p. 86.

—

Barbara Tversky: “Distortions in Cognitive Maps,” in: *Geoforum* 23/ 1992, pp. 131–138.

—

Mark D. Gross, Craig Zimring: “Predicting Wayfinding Behavior in Buildings. A Schema-based Approach,” in: Yehuda E. Kalay (ed.): *Evaluating and Predicting Design Performance,* New York 1992, pp. 367–378.

—

Patricia P. Churchland, Terrence J. Sejnowski: *The Computational Brain,* Cambridge, Mass. 1992.

—

Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides: *Design Patterns – Elements of Reusable Object-Oriented Software,* Amsterdam 1994.

—

Romedi Passini: “Wayfinding Design: Logic, Application and Some Thoughts on Universality,” in: *Design Studies,* 17, (3), 1996, pp. 319–331.

—

Karl Blossfeld: *Alphabet der Pflanzen,* with an essay by Gert Mattenklott, publ. by Ann and Jürgen Wilde, Munich 1997 (2007).

—

Holger Kantz, Thomas Schreiber: *Nonlinear Time Series Analysis,* Cambridge 1997.

—

Gary W. Evans, Janetta and Mitchell McCoy: “When Buildings Don’t Work: The Role of Architecture in Human Health,” in: *Journal of Environmental Psychology,* 18, 1998, pp. 85–94.

—

Werner Ebeling, Jan Freund, Frank Schweitzer: *Komplexe Strukturen: Entropie und Information,* Stuttgart, Leipzig 1998.

—

Gérard Raulet and Burghart Schmidt (eds.): *Vom Parergon zum Labyrinth. Untersuchungen zur kritischen Theorie des Ornaments,* Vienna 2001.

—

Cosma R. Shalizi, Jim Crutchfield: “Computational Mechanics: Pattern and Prediction, Structure and Simplicity,” in: *Journal of Statistical Physics* 104(3/4), 2001, pp. 817–879.

—

William R. Uttal: *The New Phrenology. The Limits of Localizing Cognitive Processes in the Brain,* Cambridge 2001.

—

Kari Jormakka (ed.): *Diagramme, Algorithmen, Typen,* in the series: *UmBau,* Vol. 19, Vienna 2002.

—

Jörg H. Gleiter: *Rückkehr des Verdrängten. Zur kritischen Theorie des Ornaments in der architektonischen Moderne,* Weimar 2002.

—

Special edition of *Environment & Behavior,* publ. by Ruth Conroy Dalton, Craig Zimring, University of Arizona 2003.

—

“Manifest der Hirnforscher,” in: *Gehirn und Geist,* edition 06/2004, pp. 30–37.

—

Rodney J. Douglas, Kevan A.C. Martin: “Neuronal Circuits of the Neocortex,” in: *Annual Review of Neuroscience* 27, 2004, pp. 419–451.

—

Petra Schmidt, Annette Tietenberg, Ralf Wollheim (eds.): *Patterns. Muster in Design, Kunst und Architektur,* Basel, Boston, Berlin 2005.

—

Lutz Jäncke: *Methoden der Bildgebung in der Psychologie und den kognitiven Neurowissenschaften,* Stuttgart 2005.

—

Barbara Glasner, Petra Schmidt, Ursula Schöndeling (eds.): *Patterns 2. Muster in Design, Kunst und Architektur,* Basel, Boston, Berlin 2008.

—

Entwurfsmuster. Raster, Typus, Pattern, Script, Algorithmus, Ornament, Arch+, Vol. 189, October 2008.

—

Oliver Domeisen, Francesca Ferguson (eds.): *Ornament neu aufgelegt/Resampling Ornament, exhibition catalog* for the Schweizer Architekturmuseum (SAM), Basel 2008.

—

Jörg H. Gleiter: “Von Loos bis Eisenman, Kritische Theorie des Ornaments,” in: id.: *Architekturtheorie heute,* Bielefeld 2008.

—

Jörg H. Gleiter: “Kritische Theorie des Ornaments,” in: id.: *Architekturtheorie heute,* in the series: *ArchitekturDenken,* Vol. 1, Bielefeld 2008, pp. 75–93.

—

Markus Christen: “Die Entstehung der Hirn-Computer-Analogie. Tücken und Fallstricke bei der Technisierung des Gehirns,” publ. in: *Wenn Gehirn und Computer verschmelzen,* Proceedings of the Evangelische Akademie Iserlohn, December 7–9, 2007.

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Dr. sc. ETH, is currently working at the graduate program for interdisciplinary ethics research at the University of Zurich on a project about *moral agency.* His interests include methodological questions in neuroscience and autonomy, as well as complexity of social systems and neuroethics. He also works as a freelance science writer and publicist. He studied philosophy, physics, mathematics, and biology at the University of Bern and completed his doctoral thesis in neuroinformatics at the ETH Zurich.

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Isabel Mundry

Born in 1963, composer. 1996–2005 teaches music theory and composition in Frankfurt am Main; since 2004 professor of composition at the Zurich University of the Arts. Vacation courses in Darmstadt, Madrid, Akiyoshidai (Japan), and Tong Yong (Korea), among others; visiting lecturer at music academies in Copenhagen, Tbilisi, Alcalá de Henares, etc.; 2002/2003 Fellow at the Wissenschaftskolleg Berlin. Most recent works include *Nocturno* (Premiere with the Chicago Symphony Orchestra, conducted by Daniel Barenboim, Chicago 2006), *Falten und Fallen* (Premiere with the Arditti Quartet and Andreas Staier, Salzburg 2007), *Ein Atemzug – die Odyssee* (Premiere at the Deutsche Oper Berlin, conducted by Peter Rudel, 2005). 2006, "Critics prize Premiere of the Year" for *Ein Atemzug – die Odyssee.* Isabel Mundy's compositions are published by Breitkopf&Härtel. She is a member of the Akademie der Künste in Berlin and the Akademie der Bildenden Künste Munich.

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