COMPLEXITY – DESIGN´S PROPER SUBJECT
- a foreword, 7 chunks of ideas and an outlook

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Abstract
Designing is a fuzzily defined field of various activities and artefacts and chunks of knowledge. Theories about design foundations often evoke the impression of Babylonian confusion. The reasons for this "mess" can be located in the "non-fit" of theories and subject field. There seems to be a comparable interface problem in theory-building as in designing itself.
"Complexity" and complexity theory sound promising at first glance, but turn out to be problematic and not really helpful concepts. I have argued in many cases for a more appropriate application of systemic and evolutionary concepts, which - in my view - are able to model the underlying generative structures and processes that produce the visible phenomenon of complexity. This allows to specify more clearly the "knowledge gaps" inherent in the design process. This aspect has to be taken into account as constitutive of any attempt at theory-building in design, which can be characterized as a "practice of not-knowing".
I conclude, that comprehensive "unified" and formalized complexity theories run aground on the identified knowledge gaps, which allow neither reliable models of the present, nor reliable projections into the future. On the other hand, design has always possessed the competence to manage complexity. Examining these communicative processes more clearly may provide designerly contributions to complexity theory and practice, not vice versa. New tools for design and innovation processes will deal with complexity by designing complexity.

Foreword: Complexity – some sceptical remarks

"Complexity" has been one of the buzzwords in design and design theory for at least 10 years now. Design is facing "the challenge of complexity", design is "embracing complexity", and so forth. Complexity theory is promoted as the new meta-tool for dealing with complexity. But what is complexity actually? Is complexity in design the same as complexity in complexity theory? This would make things much easier. One may solve this question once and for all, as for example Bar-Yam (1997) does at the very beginning of his seminal book by defining:
- complex = consisting of interconnected or interwoven parts / not easy to understand or analyze, and
- complexity = the amount of information needed to describe it.

These are perfect definitions with regard to formalized approaches and algorithms, as in cellular automata or in well-defined multi-agent systems. But, to give a simple example: What is the amount of information needed to describe the emotional relation of a user and his/her object of desire, which may be essential for the success of a new product?

John Horgan, in his June 1995 *Scientific American* editorial entitled "From complexity to perplexity", mentions 31 definitions of complexity and states the lack of a "unified theory". Mikulecky (2003) follows Horgan and argues that complexity is the result of the failure of the Newtonian Paradigm (which represents the world as simple mechanisms) to be generic:

> *"Complex systems and simple systems are disjoint categories that encompass all of nature. The world therefore divides naturally into those things that are simple*

and those things that are complex. The real world is made up of complex things. Therefore the world of simple mechanisms is a fictitious world created by science or, more specifically, by physics as the hard version of science. This is the world of the reductionist. It is modelled by the Newtonian Paradigm and simply needs sufficient experimentation to make it known to us. Those experiments involve reducing the system to its parts and then studying those parts in a context formulated according to dynamics. ..."

The way science is done is the modelling relation. We observe the world around us and try to make sense out of that sensory information by calling the events that make it change as we observe causality. We encode the real-world system into another system, a formal one, which is completely under our control. Once we think we have an appropriate formal system and have found an implication that corresponds to the causal event in the real world, we must decode from the formal system in order to check its success or failure in representing the causal event. This worked for a long time and is tremendously successful. But observers came up with aspects that the Newtonian Paradigm failed to capture and a new explanation was required. Mikulecky (2003):

"Complexity was born! This easily can be formalized. It has very profound meaning. Complexity is the property of a real world system that is manifest in the inability of any one formalism being adequate to capture all its properties. It requires that we find distinctly different ways of interacting with systems. Distinctly different in the sense that when we make successful models , the formal systems needed to describe each distinct aspect are NOT derivable from each other."

Irreducible "knowledge gaps" are showing up, and there will probably never be such thing as a "unified theory" of complexity. This is why I recommend to skip the concept of complexity, or rather to use it as a metaphor denoting our limits of knowing, and to turn back to the older underlying concepts of *system* and *evolution* (Jonas 1994 – 2005).

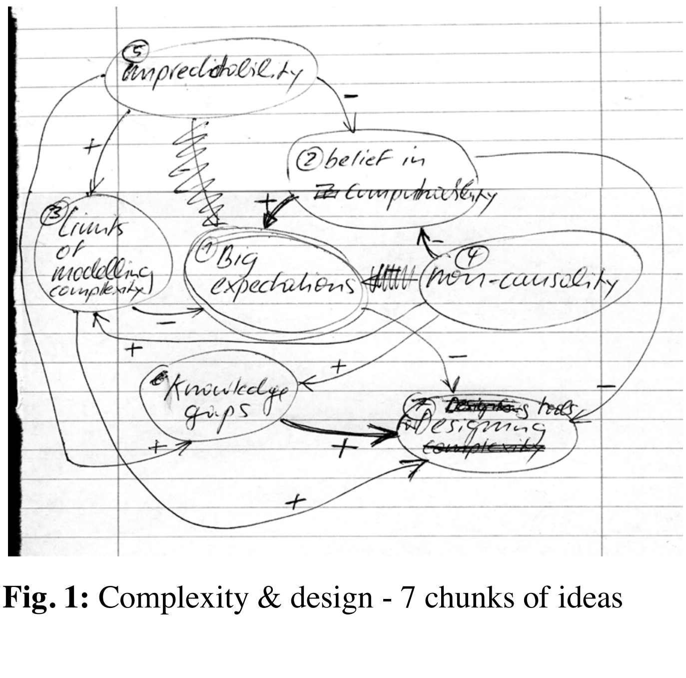

Fig. 1: Complexity & design - 7 chunks of ideas

Fig. 1 represents my complex plan for the following deliberations: a network of 7 interconnected chunks of ideas. It is, in principle, undecidable from a *logical* point of view where to begin. But, of course, it is highly relevant from a rhetorical point of view, where to start the *argument*.

1 Big expectations

We were and still are facing "big problems", indeed. We don´t have to elaborate on their nature here; they reach from satisfying more or less trivial user needs to modelling intervention strategies for changing people´s behaviour in the face of global scale challenges. Weaver (1948) states the programmatic claim that mankind will have to learn to deal with problems of *organized complexity* within the 50 years to come.

> "*... These new problems, and the future of the world depends on many of them, requires science to make a third great advance, an advance that must be even greater than the nineteenth-century conquest of* ***problems of simplicity*** *or the twentieth-century victory over* ***problems of disorganized complexity****. Science must, over the next 50 years, learn to deal with these* ***problems of organized complexity****. ...*"

Holland (1993, quoted in Horgan 1995) just reformulates the claim, introducing the concept of Complex Adaptive Systems (CAS):

> "*Many of our most troubling long-range problems - trade balances, sustainability, AIDS, genetic defects, mental health, computer viruses - center on certain systems of extraordinary* ***complexity****. The systems that host these problems - economies, ecologies, immune systems, embryos, nervous systems, computer networks - appear to be as diverse as the problems. Despite appearances, however, the systems do share significant characteristics, so much so that we group them under a single classification at the Santa Fe Institute, calling them complex adaptive systems [CAS]. This is more than terminology. It signals* ***our intuition that there are general principles that govern all CAS behavior****, principles that point to ways of solving the attendant problems.*"

Since designers started to theorize about their activities, there is the deep longing for "scientisation", for "foundations", for unified / unifying theories, that might be able to overcome the deficits compared to other disciplines. Systems- and now complexity theory seem to offer relief. Cross´ (2001) observation comes to mind, that there are 40-year cycles in design theory. Weaver´s concept of "organized complexity" was still quite vague but useful for further considerations: a more or less limited number of different elements in close dynamic interrelation – very design-like. The character of the elements and their interrelations was left open, i.e. they could mean almost everything.

Today we have dozens of definitions of complexity, from fuzzy (highly metaphorical, rich in associative meaning) to formal (without any semantic content). Which results in perplexity. Operational concepts are still rare. So, what have we learned since the first wave of systems thinking in design some 40 years ago?

2 belief in computability

The faith in computers and the concept of trans-disciplinary applicability is a remaining characteristic of many areas of systems thinking. Some critics see a tendency of research "to degenerate into computer hacking". Herbert Simon sees people "infected with mathematics" (quoted from Horgan). I do not intend to follow this generalizing critique, since I have applied computer models in many cases myself. The example (figs. 2 and 3) deals with processes of supply and demand, consumer preferences etc., and aims at intervention strategies towards sustainability. It is really impressive (mainly to oneself rather than to others) to see the apparently good relationships of model and reality: Eureka, I found a strategy for promoting more sustainable patterns of consumption! And, furthermore, it is a kind of "reward" for tedious programming efforts.

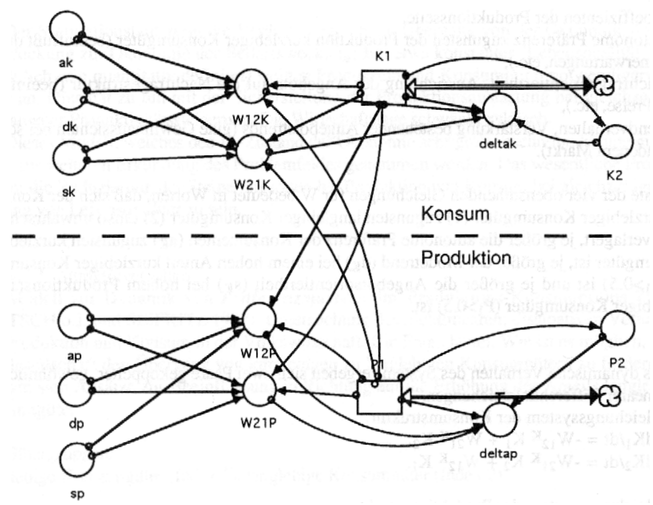

Fig. 2: Model of the production - consumption dynamics in a market (Stella II block diagram, from Jonas 1994).

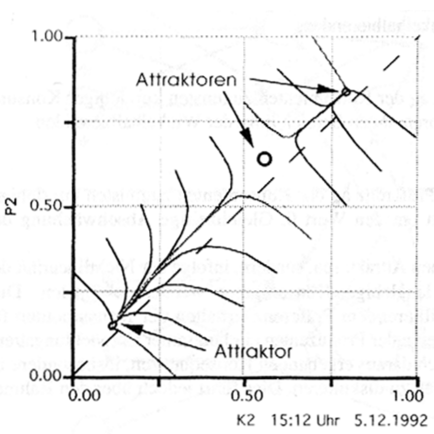

Abb. A 8: Simulationslauf Beispiel 2, Szenario 2.

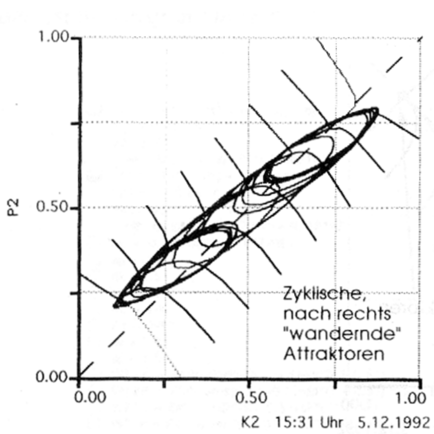

Abb. A 9: Simulationslauf Beispiel 2, Szenario 3.

Fig. 3: Simulations with different consumer preferences and market parameters (Stella II phase diagrams, from Jonas 1994).

Too many simulations or simulators suffer from what Cowan (in Horgan 1995) calls the *reminiscence syndrome*: "They say, 'Look, isn't this reminiscent of a biological or physical phenomenon!' They jump in right away as if it's a decent model for the phenomenon, and usually of course it's just got some accidental features that make it look like something."

It does not make sense at all to abandon computing approaches. But we have to think more carefully about the inherent limits of modelling complexity and we have to ask the question: *which type of computer applications are useful?* Otherwise we are caught in the mental track or trap of: "*Here is the solution – what was the problem?*"

3 Limits of modelling complexity

The field of complexity seems to be based on a *seductive syllogism* (Cowan, quoted in Horgan 1995):
(1) There are simple sets of mathematical rules that when followed by a computer give rise to extremely complicated patterns.
(2) The world also contains many extremely complicated patterns.
→ Conclusion: Simple rules underlie many extremely complicated phenomena in the world. With the help of powerful computers, scientists can root those rules out.

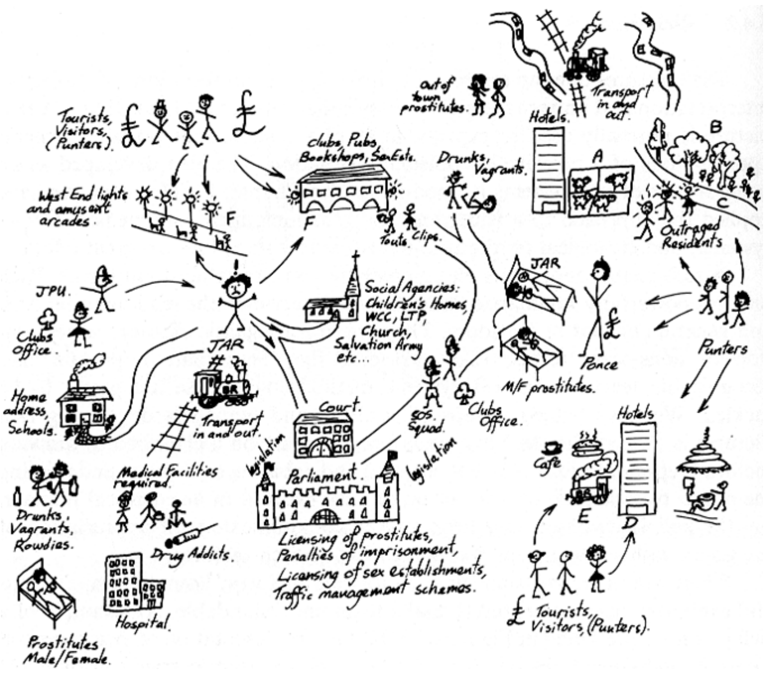

Fig. 4: Rich picture of a design situation (Flood / Carson 1993).

But we have to accept that verification and validation of numerical models of natural systems is – in principle - impossible. The only propositions that can be verified - that is, proved true - are those concerning formal systems, based on pure mathematics and logic. Our knowledge of natural systems is always partial, approximate, at best. Natural systems (and psychic and social, if we want to follow Luhmann 1984, 1997) are autopoietic systems, which follow their own internal rules. We perform the shift from 1st order observation towards 2nd order observation (which is interpretation), or from 1st order methods to 2nd order methods, or from modelling to designing (Rittel 1971/72, 1972, Glanville 1982).

Modelling is poiesis / poetics. Oreskes and her colleagues (quoted in Horgan 1995) state:

> *"Like a novel, a model may be convincing - it may ring true if it is consistent with our experience of the natural world. ...*
> *But just as we may wonder how much the characters in a novel are drawn from real life and how much is artifice, we might ask the same of a model: How much is based on observation and measurement of accessible phenomena, how much is based on informed judgment, and how much is convenience?"*

Modelling is no longer descriptive but normative, a matter of negotiation and argumentation. Modelling means designing the problem and the solution simultaneously.

4 Non-causality

There seems to be a kind of hierarchical structure of levels of reality: physical → chemical → organic → psychic → social (the latter 3 can be denoted as autopoietic systems), with non-causality (irreducibility) between and, in parts, within the levels. These splits in causality considerably limit the degree of control we can act upon these phenomena.

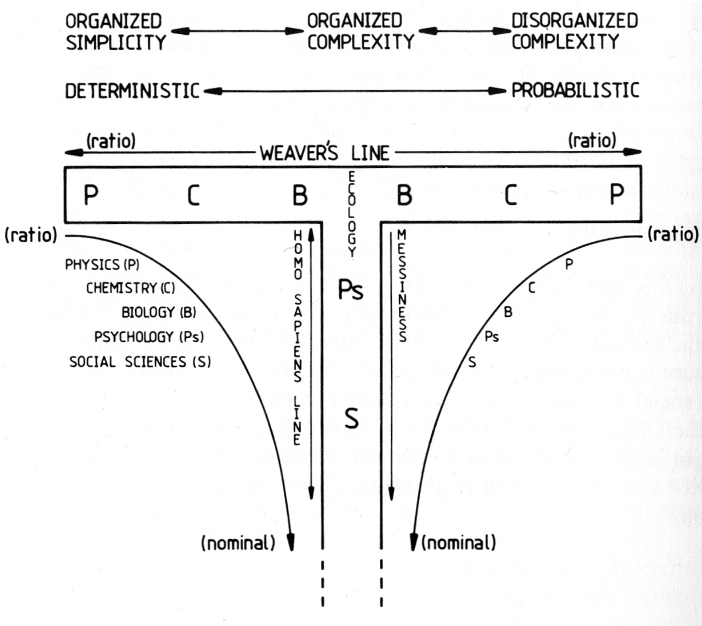

FIGURE 11.1. Unifying framework for *Dealing with complexity.*

Fig. 5: "Unifying framework for Dealing with complexity" (Flood, Carson 1993).

Flood and Carson (1993) combine Weaver´s concept of organized complexity with assertions about the type of models that are suitable for different types of systems. They differentiate the degree of quantifiabilty, by means of the scales of measurement

to be applied:
- rational (e.g. weight of objects),
- cardinal (e.g. temperature of a body),
- ordinal (e.g. sequence within a collection of things),
- nominal (e.g. names of persons).

In this figure we can "see" that the hierarchical structure of reality resists the "antireductionist" (as they call it) efforts of complexity theory, which tries to include all levels in one consistent model. At each stage, entirely new laws, concepts and generalizations are necessary. The different models are incompatible due to emergence phenomena. One could argue: Complexity theory is extremely reductionist, just because of its untenable anti-reductionist claim!

5 Unpredictability

Life (physical nature, biology, psyche, social systems) is shaped less by deterministic laws than by contingent, unpredictable, evolution-like circumstances and contexts. Luhmann (1997), in his main oeuvre, has developed an abstraction of neo-Darwinian evolution to describe the patterns of social evolution, which I consider useful for describing design processes. He differentiates the 3 causally de-coupled phases of variation – selection – re-stabilization.

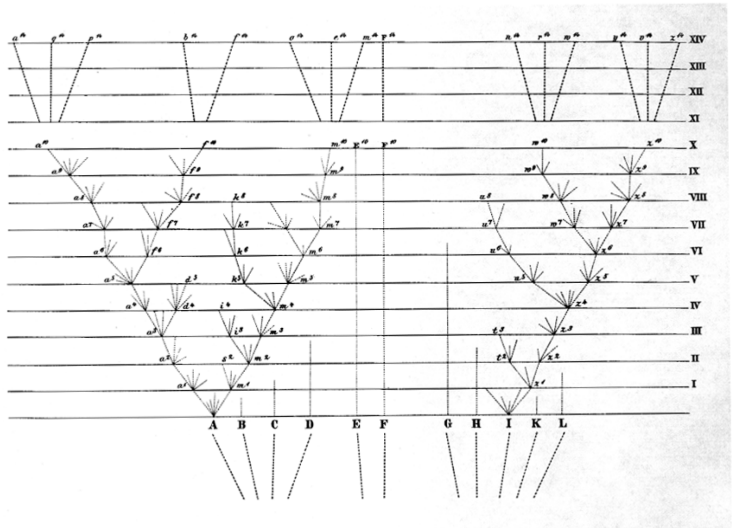

Fig. 6: Bifurcation patterns in the development of variations of a species; the only figure in Darwin´s "Origin of Species" (1859).

Circular feedback-processes of trial&error, which one may call learning, seem to be the driving forces on every level of the living world, including those socio-cultural processes, which we call planning or design. This leads to the problem of prognosis in design: we know where we come from, but we do not know where we are heading. Design methods researchers, without explicitly admitting that they are proposing evolutionary patterns, seem to know this. Existing process schemes reveal strong similarities to Darwin´s bifurcation patterns. See for example Roozenburg and Eekels (1991).

To come back to the *reminiscence syndrome:* One of the most popular algorithms in complexity theory is Feigenbaum´s logistic equation, a simple feedback mechanism, which can be used to produce this kind of evolutionary patterns: $x_{n+1} = r\, x_n\, (1-x_n)$. That means, in a metaphorical, way we "see" that design is acting "at the edge of chaos", which is the limit, where causality fails.

6 Knowledge gaps

Again: Complexity theory, claiming to be holistic, integrative, anti-reductionist, etc. turns out to be extremely reductionist and simplifying. In its claim to provide a "unified theory of everything", or, to put it more ironic, a "unified theory of interesting things", it neglects the essential differences between system types and tries to reduce these hybrid networks of designed things and autopoietic systems into simple closed formalisms. Only advanced systemic and evolutionary approaches as sketched elsewhere in much more detail (Jonas 1994 – 2005) will have a chance to contribute to more clarity regarding the knowable and the unknowable and the borderlines between these regions.

Fig. 7 denominates the gaps between *autopoietic* systems involved in designing. Design has to overcome this fundamental systemic "obstinacy", which is attempted by means of nice and common, but fuzzy and inappropriate terms such as "authorship", "creativity", "subjectivity", "values", "trends", …:
- *organisms → the "function gap"*, which indicates, that it is not a trivial task to adapt an artefact to an organism, for example, because bodies cannot speak…
- *consciousnesses → the "taste gap"*, which indicates, that it is not a trivial task, to coordinate individual consciousnesses, for example to optimise a solution for the 80 million consumers of the German market. They are all different, and they cannot speak about their taste in clear and distinct manner…
- *communications → the "fashion gap"*, which indicates, that it is not a trivial task to generalize a variety of information gathered from individual consciousnesses and to transfer this into the shape of an artefact, for example to plan a new collection of household goods for the Turkish market…

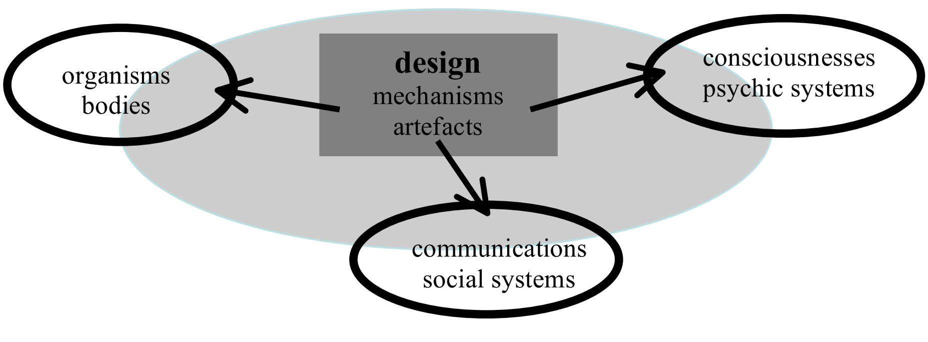

Figure 7: The "scandal of split causality", 3 autopoietic systems + design trying desparately to integrate them into a coherent whole (Baecker 2000).

7 Designing complex tools for designing

What does that mean for design and for the usefulness of complexity theory for design? I do not see any great potential in closed formal models, because we have to face the shift from representation to design. And designing means decision making under conditions of bounded rationality. The most advanced medium for bridging the irreducible knowledge gaps to arrive at decisions for acting is *language / discouse / conversation.* Concepts of complexity theory and formalisms from complexity theory can assist in this process. For example in supporting and structuring discourse (see the model of my initial sketch, fig. 1) through:

- collecting positions,
- documentig positions,
- negotiating positions,
- debating inter-relations,
- designing systemic descriptions of situations
- asking "what-if? questions
- etc.

Back to the initial question: *Which type of computer applications are useful?* Highly interactive, discoursive tools (supported by formal algorithms, of course) are able to support 2nd order observation processes among stakeholders.

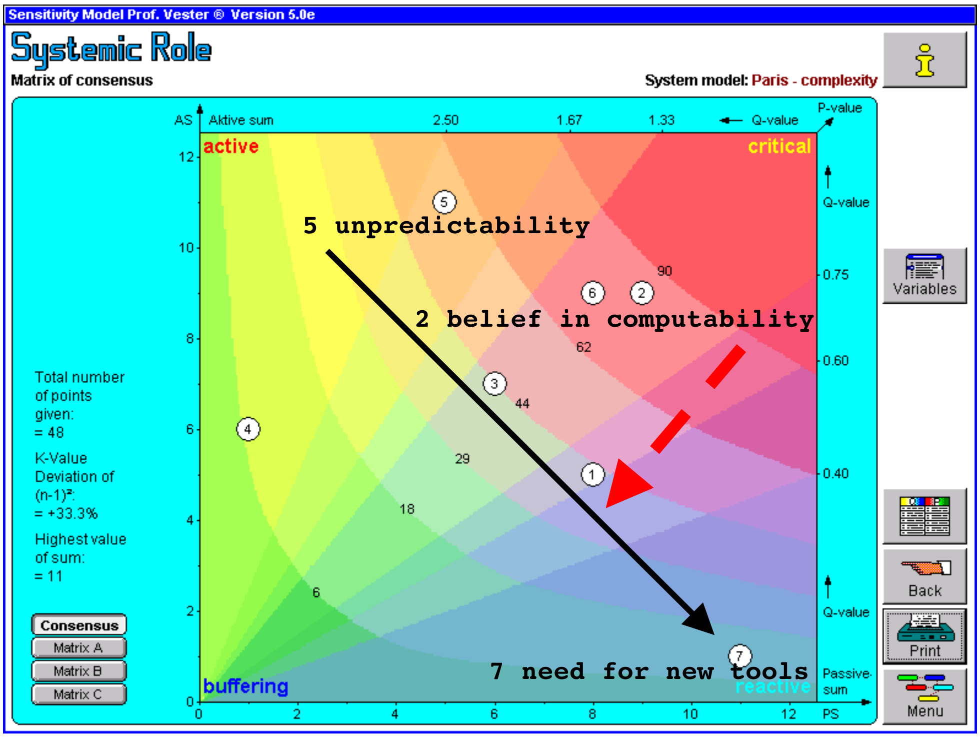

Fig. 8: Role of elements in the discoursive system as introduced in fig. 1 (Sensitivity Model, see Vester 1999).

A possible interpretation of fig. 8: "The experience and acknowledgement of unpredictability may be an active driver to promote the insight into the need for new specific tools. This is criticallly influenced by the belief in computability or 1st order cybernetic models. Computers are helpful, but computing power is secondary."

Outlook

The perspective for design research seems to be: To find procedural approaches to deal with the behaviours of interacting *autopoietic* systems. In evolutionary terms, this means a shift from 1^{st} order *prediction & control* towards 2^{nd} order *learning and design*. Communicative skills are required for dealing with complexity. Without the societal embrace of scientific and technological development, no collective or individual meaning can be assigned to the production of complex new knowledge and artefacts. Without their embedding in persons and their relations, in things and in the self as well as in institutions, the necessary social skills to put this knowledge to beneficial use in concrete and heterogeneous situations, will not arise. Or, as Nowotny (2005, 28,29) puts it: *"A deeper theoretical understanding of complexity, not as a mathematical, but as a social phenomenon is required, which can be usefully guided by metaphors taken from mathematical complexity theory."*

Maybe now we have a better idea, why "designing for people" (Jones 1970) or even "for the real world", is so difficult: The entire real world is complex! Complexity science may be helpful here, but is not at all to be considered as a panacea. *Design is too complex for complexity science! New tools for design and innovation processes will deal with complexity by designing complexity. These approaches may turn out to be designerly contributions to complexity theory and practice.*

... to be continued.

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