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Designing in the real world is complex anyway - so what? Systemic and evolutionary process models in design

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ABSTRACT

Designing is a heterogeneous, fuzzily defined, floating field of various activities and chunks of ideas and knowledge. Available theories about the foundations of designing as presented in "the basic PARADOX" (Jonas and Meyer-Veden 2004) have evoked the impression of Babylonian confusion. We located the reasons for this "mess" in the "non-fit", which is the problematic relation of theories and subject field. There seems to be a comparable interface problem in theory-building as in designing itself.

"Complexity" sounds promising, but turns out to be a problematic and not really helpful concept. I will argue for a more precise application of *systemic* and *evolutionary* concepts instead, which - in my view - are able to model the underlying generative structures and processes that produce the visible phenomenon of complexity. It does not make sense to introduce a new fashionable meta-concept and to hope for a panacea before having clarified the more basic and still equally problematic older meta-concepts.

This paper will take one step away from "theories of what" towards practice and doing and try to have a closer look at existing process models or "theories of how" to design instead. Doing this from a *systemic perspective* leads to an *evolutionary view* of the process, which finally 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" theories, or methods, or process models run aground on the identified knowledge gaps, which allow neither reliable models of the present, nor reliable projections into the future. Consolation may be found in performing a shift from the effort of *adaptation* towards strategies of *exaptation*, which means the development of stocks of alternatives for coping with unpredictable situations in the future.

Keywords: Design process models, complexity, systems, evolution

1. 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? Is complexity in design the same as complexity in complexity theory? This would make things much easier. One may solve this question, 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 be no "unified theory" of complexity. This is why I recommend to skip the concept of complexity (or to use it as a metaphor denoting our inability) and turn back to the older concepts of *system* and *evolution*.

2. DESIGN PROCESS MODELS – A GENEALOGICAL SKETCH

Stated in the most general manner, a design task consists in transferring an existing state of a "system" into a preferred one, whereby "system" will normally be considered as some kind of complex (!) "whole", consisting of elements and relations between these elements. The preferred state can be defined as an optimal "fit" of the system or artefact and its environment. The artefact is what designers design, whereas the environment consists of the constraints that have to be met and which cannot be directly controlled by design. The "interface" region between the artefact and the environment is the "location" of design activities (Alexander 1964, Simon 1969).

The system concepts in design as used in "complex systems" appears to be rather simplistic. There is hardly any reference to the elaborate thermodynamic and biological theories of open / dissipative / closed systems, which explain how systems are able to keep a state of high order far from equilibrium, thus temporarily overcoming the 2nd law of thermodynamics. Systems concepts in design are mainly based on simplified applications of Wiener's *cybernetics* (Wiener 1948), dealing with mechanisms of *feedback, communication and control* in goal-oriented processes. He explicitly warned of any hope that his approach could contribute to the healing of the diseases of society.

Weaver's concept of *"organized complexity"* (Weaver 1948) filled the obvious gap between the classical Newtonian concepts of "problems of simplicity" and "problems of disorganized complexity" and might have provided a powerful basis for dealing with complex social problems / design problems. This was his enthusiastic programmatic appeal for the next 50 years; but his approach was neglected in favour of *computability*.

Operations Research (OR) can be regarded as the first application of systems thinking in "designerly" processes, such as planning and engineering, from the 1950s onward. The problem-solving process in OR consists of the definition of the solution space, the formulation of the measure of merit, the fixing of constraints, and the optimisation process, leading to a local or global optimum. This was tremendously successful, as e.g. the big NASA projects prove.

The design methods movement in the 1960s adopted and developed these approaches. Symbolic models of the design problem have to be built, consisting of factors, which describe the problem situation and causal relations between these factors. Ideally, the solution criterion is given in a quantitative manner, as a measure of merit function (even aesthetic criteria have been treated in this way, as we know). Numerical optimisation methods based on closed mathematical calculus or iterative heuristic algorithms can be applied to this problem type. The problem space has to be limited and well-known, and if the problem is properly stated, then the solution is just a re-formulation of the problem, or a change of representation, which can be carried out by means of the same symbolic language that was used for the problem definition (Simon 1969). But unfortunately, this has never been the normal situation in design.

Design problems may be categorized according to the parameters *problem / solution space* (elements + relations available), which can be either limited or open, and *solution criterion* (measure of merit), which can be either quantitative or qualitative, which means influenced by ethical and aesthetic factors. Entirely numerical solutions are possible, if the solution space is *limited* and the solution criterion is of *quantitative* nature, which is the case, for example, in a chess problem or in the optimisation of a streamlined shape according to aerodynamic criteria. In all other cases we have value-laden solutions of ethical or aesthetic nature (even the apparently highly quantitative problem to bring a man to the moon has a large number of qualitative subtasks, as for example the interior human-machine interface of a vehicle). Value-based decisions of minor or major impact have to be taken at various moments during the solution process.

As soon as the relevant environment of a design problem is no longer natural, but influenced by psychic or social aspects, then the concept of *time* in the process is changing. Systems have memories and imagination. Time is no longer a linear parameter, the "fourth dimension", but the source of uncertainty. The future can be conceived as a *projective space*, determined not only by natural trajectories, but by plans, wishes, hopes, fears, decisions, etc. In other words: it is a space of imagination. The development of psychic and social situations is proceeding in highly unpredictable ways; the fit between the artefacts and the environments will probably disappear before long.

What about remaining prediction capabilities for the *future* fit of solutions in *non-natural* contexts? The question comprises the issue of *"how do we want to live?"*, and marks the shift from "first-generation" to "second generation" methodology, which is closely connected to Horst Rittel (1972). In his view, first-generation methods seem to start once all the truly difficult questions have been dealt with already. He introduced the notion of "wicked problems" and tried to denote the *limits of rationality* related to this kind of problems. Rational behaviour means the attempt to foresee the consequences of intended actions, which results in various dilemmas and paradoxes, for example that the more rational one is in discovering the causal chains of future consequences of interventions, the more one is disabled to act.

According to Rittel, these dilemmas have to be overcome by opening up the closed algorithmic problem solving process and initiating a process of *argumentation* and *negotiation* among the stakeholders instead. In other words: he suggests a change from 1st order cybernetics to 2nd order cybernetics: not systems are observed, but systems observing systems. This introduces, as a central new part, the *design of the "problem" itself*. Under conditions of second order observation we have to account for the fact, that the problem itself is not "given", but has to be constructed by the stakeholders. In consequence, problems are changing their character in the course of the solution process. No information is available, if there is no idea of a solution, because the questions arising depend on the kind of solution, which one has in mind. One cannot fully understand and formulate the problem, before it is solved. Thus, in the end, the solution is the problem. Therefore Rittel argues for the further development and refinement of the argumentative model of the design process and the study of the logic of the designers' reasoning, where logic means the rules of asking questions, generating information, and arriving at judgements.

In view of this situation Rittel (Cross 1984: 326) states in his slightly ironic manner:

"All of which implies a certain modesty; while of course on the other side there is a characteristic of the second generation which is not so modest, that of lack of respect for existing situations and an assumption that nothing has to continue to be the way that it is. That might be expressed in the principle of systematic doubt or something like it. The second-generation designer also is a moderate optimist, in that he refuses to believe that planning is impossible, although his knowledge of the dilemmas of rationality and the dilemmas of planning for others should tell him otherwise, perhaps. But he refuses to believe that planning is impossible, otherwise he would go home. He must also be an activist."

John Chris Jones (1970) puts it more general and metaphoric, when emphasizing the necessity of designing the design process itself. A considerable part of the design capacities has to be re-directed from the problem to the process. The designer as "black box" (the artist) as well as the designer as "glass box" (the follower of 1st generation methods) have to change their attitude towards a self-conception of *designer as "self-organizing system"*, who is observing the evolving artefact plus himself observing the evolving artefact.

3. INHERENT PATTERNS – CIRCULARITY AND AUTOPOIESIS

Circularity as a characteristic of problem-solving and purposive design processes is showing up. We know DO - loops as instructions for iterative processes in formal languages in software-programming. We know the TOTE - scheme (Test - Operate - Test - Exit) from cognitive psychology (Miller et. al. 1960) as the prototypical pattern for dealing with iterative heuristics and feedback in design methods. Most of these design methods consist of linear sequences of steps of specific subtasks plus TOTE cycles for the necessary feedback. Opaque systems, called *"black-boxes"* are rendered "white" and manageable by means of circular feedback-models. Human agents act as detached operators of these "machines". Thus systems have been typically treated mechanistically as open (for matter, energy and information), and in interaction with their context, transforming inputs into outputs as a means of creating the conditions necessary for survival. Changes in the environment are seen as input stimuli, to which the system must respond in defined manners.

The concept of *autopoietic closure* in living and meaning-based systems is essential for the further argument concerning design processes. Autopoiesis characterizes the self-referential logic of self-(re)producing systems. Maturana and Varela (1985) argue, that living systems are organizationally closed, i.e. without any input or output of control information. Operations only refer to themselves and the system's internal states. The impression, that living systems are open to an environment, results from an attempt to make sense of such systems from the perspective of an outside observer. If at all, "black boxes" can only temporarily be "whitened" by means of an interaction of observer and observed (Glanville 1982). The aim of autopoietic systems is ultimately to maintain their own identity and organization. A system cannot enter into interactions that are not specified in the pattern of relations that define its organization. In this sense the system's environment is really a part of itself. The theory of autopoiesis thus admits that systems can be recognized as having "environments", but insists that relations with any environment are *internally* determined; systems can evolve only along with *self-generated* paths.

The theory of autopoiesis encourages us to understand the transformation of living systems as the result of internally generated change. Rather than suggesting that the system merely *adapts* to an environment or that the environment *selects* the system configuration that survives, autopoiesis places principal emphasis on the way the total system of interactions shapes its future and evolves. Autopoiesis presents a modification of Darwinian theory: while recognizing the importance of system variation and the retention of "selected" features in the process of evolution, the theory offers different explanations as to how this occurs. Changes are eventually induced, but not directed by means of perturbations from outside. The emphasis is shifting from adaptation of a system to its environment towards *co-evolution of autonomous systems*.

Morgan (1986: 245) was one of the first to apply the biological concept of autopoiesis to a design-related field, namely organization theory:

" When we recognize that the environment is not an independent domain, and that we don´t necessarily have to compete or struggle against the environment, a completely new relationship becomes possible. For example, an organization can explore possible identities and the conditions under which they can be realized. Organizations committed to this kind of self-discovery are able to develop a kind of systemic wisdom. They become more aware of their role and significance within the whole, and of their ability to facilitate patterns of change and development that will allow their identity to evolve along with that of the wider system."

This is a very positive interpretation of autopoiesis, and probably a step forward with respect to the problems of organizations. But it still neglects the fact that the environments of autopoietic systems consist of various other, equally stubborn autopoietic systems. Luhmann (1984) has formulated this radical generalization of biological autopoiesis. He extends it for the purpose of describing mental and social systems. His theory of social systems provides more delicate instruments for an identification of the problem and a composed deconstruction of unfounded expectations in design theory. Organizations, as described by Morgan, are one of several sub-categories of communicative / social systems, all of which are operationally closed, autopoietic systems. Living systems act in the medium of life, mental systems in consciousness, and social systems in communication. Both mental and social systems operate with *language* and *meaning*. Communication cannot happen without presupposing consciousness and vice versa, nevertheless both are closed, without any transfer of information. Language, which Luhmann calls a "variation mechanism of socio-cultural evolution", is the ultimate instrument for coupling mental and social systems. This strange, fuzzy, non-causal coupling, called *interpenetration*, seems to be the most powerful driver of human evolution and learning.

4. EVOLUTIONARY EPISTEMOLOGY – RECOGNITION AND EXPLANATION

The epistemic characteristic of design can be assumed as *learning process*. This process can be considered as biological, grounded in the need of organisms to survive in an environment. The aim cannot be final "true" representation of some external reality, but rather a process of *(re-) construction* for the purpose of appropriate *(re-) action*. Yet Aristotle suspected, that the recognizability of the world must rely on the fact, that there is a kind of similarity between the "particles" of the world and those in our senses. The history of biological evolution suggests similarities of the way the material world is structured and the way we think of it. Evolutionary epistemologists (Campbell 1974) argue, that the Kantian transcendental apriori has to be replaced by the assumption of an *evolutionary fit* between the objects and the subject of recognition.

The evolutionary model of knowledge production presents a scheme with structural identity from the molecular up to the cognitive and cultural level (Riedl 2000). The basic structure reveals a circle of trial (based upon expectation) and experience (leading to success or failure, confirmation or refutation), or of action and reflection. Starting with passed cases, the circle consists of an inductive / heuristic semi-circle with purposeful learning from experience, leading to hypotheses and theories and prognoses about how the world works, and a deductive / logical semi-circle, leading to actions and interventions, which result in the confirmation or refutation of theories due to new experiences, etc. Internal or external perturbations (called ideas, creativity, curiosity, … or accidents, environmental changes, …) influence the circle, leading to stabilizations (negative feedback) or amplifications and evolutionary developments (positive feedback).

Only very recently in the cultural evolution this general scheme was split into the "ratiomorphous" (the term was coined by Konrad Lorenz) systems of recognition and the rational systems of explanation / understanding, with its most extreme form: the logical positivist dualism of "context of discovery" (acting) vs. "context of justification" (thinking). While the ratiomorphous process of recognition has a high potential in dealing with complex, evolving phenomena, it is not always useful for causal explanations, and vice versa. But this "dilemma" is not inherent in the nature of knowledge production, but rather a consequence of the dualistic concept, which we have imposed on the process. The path from recognition to explanation is continuous and circular, sometimes with dead ends. Our language is too poor, or, too much locked in the "black&white" tradition, to express the beautiful transitory shades of "grey" between the poles.

Table 1. Recognition vs. Explanation (Riedl 2000: 53 – 55).

Recognition (Erkennen)	Explanation (Erklären / Verstehen)
- networks, many causes	- linear cause – effect relations
- simultaneous (simul hoc)	- sequential (propter hoc)
- 4 Aristotelian causes considered	- only causa efficiens considered
- only local validity, context is crucial	- global validity claimed, context excluded
- allows no experiments, mostly irreversible	- relies on experiments, mostly reversible
- prognosis is projection	- prognosis is forecasting
- correspondence of organism / artefact in a milieu	- coherence of elements inside a system
- reaches into high complexity	- reduces complexity
- fitness, “truth” means strong design	- “truth” means correct causal relations
- is labelled “pre-scientific”	- is labelled “scientific”

The argument of *naturalized epistemology* appears in various forms. John Dewey (1986) argues that processes of circular action, driven by intention, are the essential core of knowledge generation. The separation of thinking as pure contemplation and acting as bodily intervention into the world becomes obsolete; quite the reverse: Thinking depends on real world situations that have to be met. Thinking activity is initiated by the necessity to choose appropriate means with regard to expected consequences. The projected active improvement of an unsatisfactory, problematic situation is the primary motivation for thinking, designing, and, finally - in a more refined, purified, quantitative manner - for scientific research and knowledge production. According to Dewey, knowing is a manner of acting and "truth" is better called "warranted assertibility".

To come back to design: Schön´s (1983) epistemology of "reflective practice" can be regarded as the design-related description of these concepts. It is this unspecific pattern, which Cross (2001) characterizes as "designerly ways of knowing":

"The underlying axiom of this discipline is that there are forms of knowledge special to the awareness and ability of a designer, independent of the different professional domains of design practice."

Evolutionary epistemology uses the most basic generative mechanism to explain learning in the living world, thus explaining the ongoing production and re-production of both artefacts and knowledge, finally of design and science as dynamic forms. This is the "essence", and there is no need for any specific nature of knowing in design. The theory of socio-cultural evolution seems to be a useful framework to denote the unpredictability of design developments and project outcomes, thus the limits of causal explanations, in a scientific manner.

5. SOCIOCULTURAL EVOLUTION – APPLICATION TO DESIGN

Autopoietic systems show a high independence from internal and external perturbations (negative feedback compensates for the irritations). On the other hand it is one of the insights of chaos theory, that circularity in simple mathematical models, can cause so-called *deterministic chaos.* Minimal differences in initial conditions of the system parameters can cause completely different outcomes, so that predictability of final states is lost (positive feedback amplifies perturbations and triggers evolutionary change). Natural evolutionary patterns of development, with their sequence of stable phases and sudden variations seem to be based on an interplay of negative and positive feedback mechanisms. The evolution of artefacts shows similar patterns (Fig. 1).

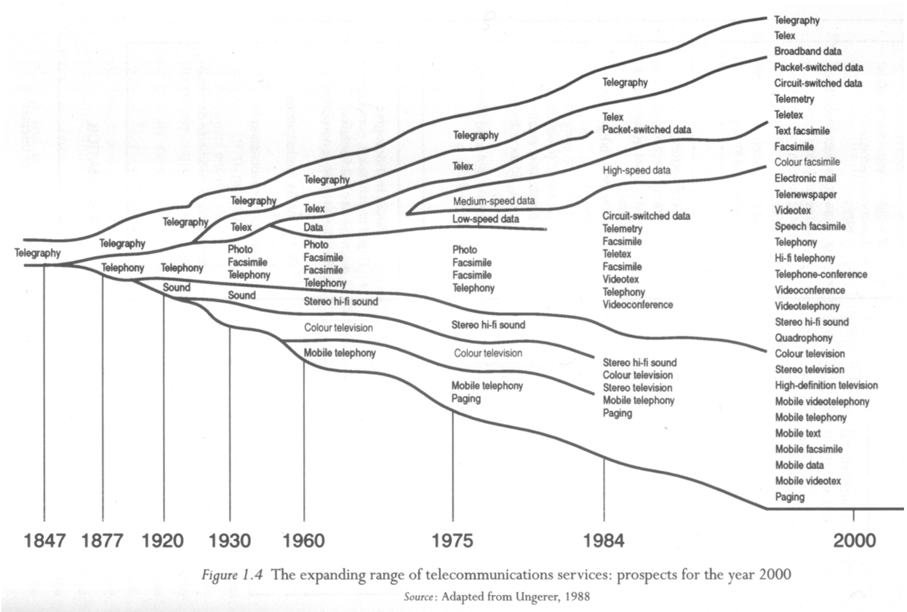

Figure 1. Evolution of artefacts (Graham and Marvin 1996).

Hybs and Gero (1992) describe artefacts as entities struggling for the survival of the fittest in the hostile environment of the market; but the approach is still sub-complex. We (seem to) know where we come from, but we do not know, where we are going. At least we know the ancestors of our current artefacts, which means some interpretation capacity for design history. Nevertheless we normally do not know the influences that acted upon the bifurcation situations and resulted in exactly this and no other development.

Also representations of design processes reveal these patterns (fig. 2). The nicely cut branches after the bifurcation points suggest, that there is a rational means to overcome the indeterminacy, to take a decision, which provides more than a random chance, that the decision is viable in the future. Rittel (1971/72: 48, 54, translation W.J.) comments this laconic:

"Constrictions are not 'natural conditions' but deliberate restrictions of the variety of solutions, mostly implicit signs of resignation. ...

... In reality there is no opposition / sharp conflict between an ... intuitive approach to solve a problem and ... a controlled, reasonable and rational approach. The more control one wants to exert, the more well-founded one wants to judge, the more intuitive one has to be.

The endpoints in the more and more ramifying tree of causal explanations are always spontaneous judgements."

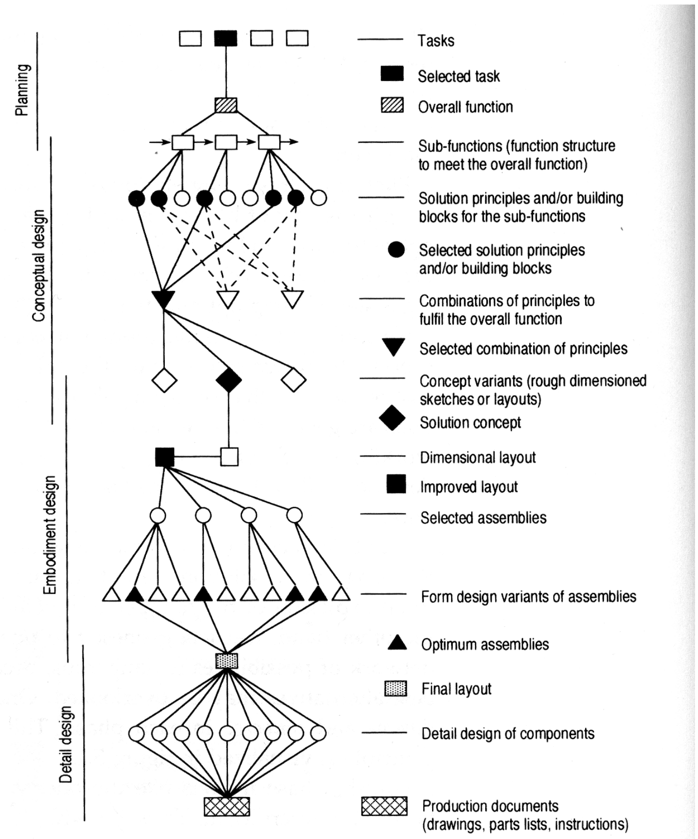

Figure 5.12 Divergence and convergence in the design process. The shadowed elements indicate the chosen points of departure for the next phase (source: VDI 2222).

Figure 2. Bifurcation cascades in the design process (Roozenburg and Eekels 1991).

These evident analogies in the processual patterns of natural and artefact evolution suggest the application of basic evolutionary concepts to the design of artefacts. No 1:1 analogies are sought; of course variation in a meaning-based context is different from variation in organisms. Thus, if we are aiming at new descriptions and tools for the design process, we have to identify the elements and processes of natural evolution, which can be transferred to the evolution of artefacts. We should focus on the problem of increasing the probability of success with respect to a decision to be taken.

Luhmann's theories are closely related to evolutionary epistemology. In his main oeuvre (1997) he has started to work out the concept of *social evolution*. Evolution theory is based upon the *system / environment* distinction; it is this difference, which enables evolution. Evolution theory does not distinguish historical epochs, but the circular sequence of *variation*, *selection*, and *re-stabilization*. It serves for the unfolding of the paradox of "the probability of the improbable". Re-stabilization is essential, because it is the condition for variation and selection being possible at all. Evolution theory thus explains the emergence of essential forms and substances from the accidental, relieving us of attributing the order of things to an form-giving telos or origin. It simply turns the terminological framework of world-description upside-down. Evolution theory is not a theory of progress, and it does not deliver projections or interpretations of the future. Autopoiesis, as outlined above, enforces a revision of the concept of "adaptation". Adaptation is a condition, not the goal or outcome of evolution: on the basis of being adapted it is possible to produce more and more risky ways of non-adaptation - as long as the continuation of autopoiesis is guaranteed.

The three separated processual components of evolution can be related to the components of society, conceived as a communicative / social system:

- *Variation* varies the *elements* of the systems, i.e. *communications*. Mainly variation means deviating, unexpected, surprising communication. It may simply be questioning or rejecting expectations of meaning. Variation produces raw material and enables further communication with more open connections than before.

- *Selection* relates to the *structures* of the system, i.e. the creation and use of *expectations* that control communication. Positive selection means the choice of meaningful relations that promise a value for building or stabilizing structures. Selections serve as filters to control the diffusion of variations. Religion has been such a filter. Truth, money, power, as symbolically generalized media serve as filters in modern societies.

- *Re-stabilization* refers to the state of the evolving *system* after a positive / negative selection. It has to take care of the *system-compatibility* of the selection. Even negative selections have to be re-stabilized, because they remain in the system's memory. Today stability itself becomes a more and more dynamic concept, indirectly serving as a trigger for variation.

Variation, selection and re-stabilization can be related to the empirical reality of evolving systems, thus allowing its re-interpretation in the light of evolution theory. For example:

- *Early segmented* societies (families, clans, …), where communication mainly happens as interaction between people present, hardly need the distinction of variation and selection, because every interaction is aiming at immediate acceptance or refusal.

- *Stratified hierarchical* societies have problems to differentiate between selection and re-stabilization, because the main criterion for selection is stability.

- *Modern differentiated* societies differentiate variation / selection as well as selection / re-stabilization, but have problems to distinguish re-stabilization and variation, because stability is of extremely dynamic character and provides the trigger of evolutionary variation. Here we may identify designing, the deliberate, purposeful creation of variety, as a constituent of modernity.

6. THE PROBLEMS OF CONTROL AND PREDICTION – CAUSALITY GAPS

The previous findings allow us to summarize as follows: Designing consists of interacting and co-evolving autopoietic systems and artefacts. Random mutations in nature plus deliberate decisions and accidental events and connections in social life initiate open-ended processes of self-organization, in which positive and negative feedback interact and produce changing patterns that may at some point assume relatively stable forms, called fashions or trends. This kind of mutual causality implies, that it is not possible to exert unilateral control over any set of variables; interventions are likely to reverberate throughout the whole. Though it is often possible to spot an initial "kick" that sets a system moving in a particular direction, it is important to realize, that to our understanding such kicks are not the cause of the end result. They merely trigger transformations embedded in the logic of the systems involved.

We can identify two problem areas: (1) *control*, due to the system / environment distinction, and (2) *prediction*, due to the variation / selection / re-stabilization distinction.

(1) The problem of control:

Luhmann' systems theory provides a map of the possible gaps related to these interventions, called design (Fig. 3). Artefacts as artefacts are assumed to function; this is not the primary task of designing. With respect to the autopoietic systems, I introduce the following gaps, which are always occurring in interaction with different shares, according to the specific design task:

- *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…

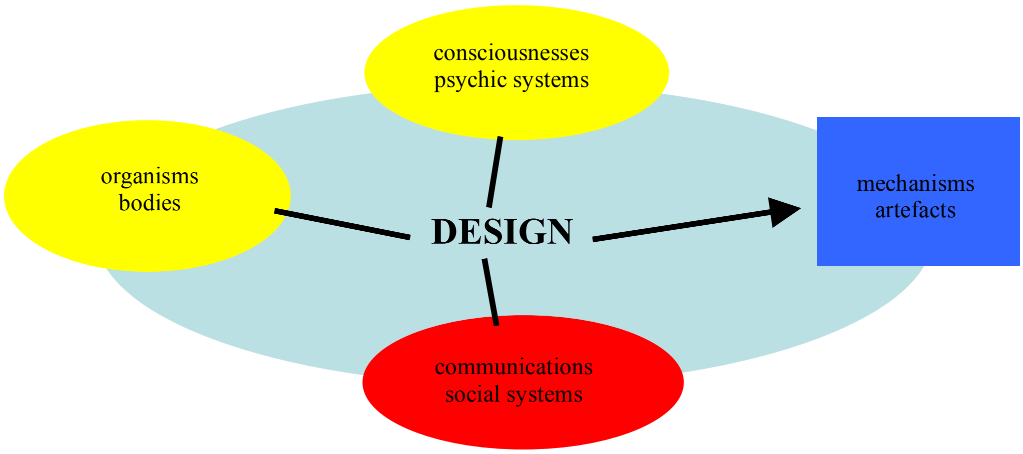

Figure 3. The "scandal of split causality", 3 autopoietic systems + design (Baecker 2000).

(2) The problem of prediction:

- *Variation* is aiming at alternatives. This is no problem, since consciousnesses provide abundant "creativity", which is essential for increasing the variety of choice. This is the "timeless" task of *designing artefacts*…

- *Selection* is aiming at the fit of alternatives into structures. This is a problem indeed, because communicative structures are detectable, but not their future stability. Single aspects can be tackled by isolated approaches: organism - artefact gaps by means of ergonomics, consciousness - artefact gaps by means of cognitive ergonomics, communication – artefact gaps by means of market research, etc. So, to a certain degree, *design research* can examine *existing structures*…

- *Re-stabilization* is aiming at the integration of selected alternatives into the system. There is hardly any predictability, because this is a question of long-term viability of selected alternatives within communicative systems. *Futures studies* and *scenario planning* are dealing with *evolving systems*…

Returning to design: The present does not at all mark the "wave front" of progress, but merely consists of what has remained from the past. And so it happens, that we do not live in the best of all possible worlds. Harmony, if at all, is "post-stabilized" harmony, created in our narratives. The study of failed innovations ("floppology") might be a promising approach to improve designing: the "dark side" of the field is probably much richer than the "best practice" view. Design activities happen "in-between", they intervene into the relations of co-evolving autopoietic systems by means of creating artefacts that pretend to improve those relations. The basic problem is neither lacking individual creativity nor insufficient planning, but the *uncontrollable* and *unpredictable* nature of communication in the environment of the artefacts. The most developed instrument for bridging this kind of causality gaps between psychic systems is *language*, which enables communication. Functioning communication is highly improbable. Functioning design is even more improbable…

7. CONCLUSION

To sum up: there are two basic problems related to systemic gaps:

(1) The gaps between *autopoietic* systems involved in designing. This is fundamental systemic "obstinacy", which is labelled or covered with the nice and common, but fuzzy terms "creativity", "subjectivity", "values", "trends", …

(2) The gaps between the *evolutionary* mechanisms involved in designing. Or: the future orientation of design activities. The artefact, once released, remains as it is. The environments of the artefact change in manners, which are *in principle* unpredictable.

At this point I have reached the limits of my argument. Even a perfect language could only bridge one single gap: the interface between a thought, which is an element of a consciousness, and the communicative offer produced by this psychic system. And this kind of ideal language would have to be a private language, which would probably fail with the addressee. A functioning language has to be a deficient compromise, *a medium*. And *design is a medium as well*, but a considerably less universal one compared to language. Language is deficient, but nevertheless optimal. *Language is the problem and the solution.*

The perspective for design research seems to be: To find procedural / practical approaches to deal with the *unpredictability* of the behaviours of interacting *autopoietic* systems. In evolutionary terms, this means a shift from *prediction & control* towards *learning and design*, or: a shift from efforts of *adaptation* towards strategies of *exaptation*, which means the development of stocks of alternatives for meeting unpredictable situations in the future.

In other words: the choice of process models and methods does not matter, as long as you believe in their projective power and convince others of it. Complexity science may be helpful here, but is not at all to be considered as a panacea. *Design is too complex for complexity science!* 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!

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