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Research through DESIGN through research

A cybernetic model of designing design foundations

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Abstract

Purpose – The paper seeks to make a substantial contribution to the still controversial question of design foundations.

Design/methodology/approach – A generic hypercyclic design process model is derived from basic notions of evolution and learning in different domains of knowing (and turns out to be not very different from existing ones). The second-order cybernetics and evolutionary thinking provide theoretical support.

Findings – The paper presents a model of designerly knowledge production, which has the potential to serve as a genuine design research paradigm. It does not abandon the scientific or the hermeneutic or the arts & crafts paradigm but concludes that they have to be embedded into a design paradigm. “Design paradigm” means that “objects” are not essential, but are created in communication and language.

Research limitations/implications – Foundations cannot be found in the axiomatic statements of the formal sciences, nor in the empirical approaches of the natural sciences, nor in the hermeneutic techniques of the humanities. Designing explores and creates the new; it deals with the fit of artefacts and their human, social and natural contexts. Therefore foundations for design (if they exist at all) have to be based on the generative character of designing, which can be seen as the very activity which made and still makes primates into humans.

Practical implications – The hypercyclic model provides a cybernetic foundation (or rather substantiation) for design, which – at the same time – serves as a framework for design and design research practice. As long as the dynamic model is in action, i.e. stabilized in communication, it provides foundations; once it stops, they dissolve. The fluid circular phenomena of discourse and communication provide the only “eternal” essence of design.

Originality/value – “Design objects” as well as “theory objects” are transient materializations or eigenvalues in these circular processes. Designing objects and designing theories are equivalent. “Problems” and “solutions” as well as “foundations” are objects of this kind. This contributes to a conceptual integration of the acting and reflecting disciplines.

Keywords Design, Cybernetics, Evolution, Learning, Research, Knowledge management

Paper type Research paper

1. Introduction: problem statement and motivation

The paper is motivated by the still controversial issue of (lacking) design foundations. They can neither be found in the axiomatic statements of the formal sciences (logic, mathematics, etc.), or the empirical approaches of the natural sciences (physics, biology, etc.), nor in the hermeneutic techniques of the humanities (language, literature, history, etc.). Available theories about the foundations of designing evoke the impression of Babylonian confusion (Jonas and Meyer-Veden, 2004). Reasons for this mess may be found in the “non-fit” of theories and their subjects (Glanville, 2005).



There seems to be a comparable interface problem in theory-building as in designing itself. Designing explores and creates the new; it deals with the functional and symbolic fit of artefacts and their human, social and natural contexts of use. Therefore, foundations for design should be based on the processual and generative character of designing itself, which can be regarded as the human activity that made and still makes primates to humans.

Design has become a profession, mainly rooted in arts and crafts traditions, and – later in its development – an academic discipline. More recently design has been discovered as a central driver of social and economic innovation, which now has to clarify its position in the university context. If disciplinary autonomy, inter-disciplinary acceptance and social effectiveness is to be achieved, then this cannot be done with reference to the sciences (as mentioned above), or to the equally inappropriate arts and crafts tradition. Findeli and Bousbaki (2005) proposed three historical stages in design research: *aesthetics*, referring to object-centeredness, *logic*, referring to rational process models, and *ethics*, referring to user experience in their engagement with the designed environment. In this most recent perspective, the aesthetic or functional object cannot be in the focus any more, but rather the processes of generation and use.

Regardless of these changes, the improvement of “quality of life” may still be considered as design’s ultimate purpose. Modernist design claimed to meet people’s needs by means of nineteenth century scientific approaches. Solutions were conceived by simple mechanistic answers to seemingly “real” needs, which had been determined by means of statistical methods. Ideological bias guided the determination of these needs; enthusiastic misinterpretations of the potential of the sciences lead to expectations of boundless progress. A striking example is the use of simplified and misinterpreted concepts of purpose-oriented evolution, leading to ideological positions as the notorious “form follows function” which has been impressively analyzed by Michl (2002). This modernist “belief in science” applied to major parts of the design methods movement (DMM) of the 1960s. And it still applies to parts of the current “Design research movement” (DRM, my own term, W.J.), which started in the 1980s. The paper outlines an alternative foundation/substantiation (maybe a constructivist position has to content itself with “substantiation” of a theory instead of “foundation” of a discipline).

2. Guiding ideas in design research: for users and/or for design itself?

Because of the hybrid nature of design research (looking for knowledge + aiming at real world improvements) the DRM addresses two related issues:

- (1) internally, regarding the disciplinary status: how can design become a respected academic field of knowledge production? and
- (2) externally, regarding design’s benefit for society: how can design contribute to human-centred innovation?

The adoption of scientific standards immediately contributes to design’s academic respectability. Nonetheless, this strategy has a price, since it fails to substantially contribute to tackling practical issues of social and economic innovation and human well-being. Two reasons are:

- (1) The failure of de-contextualized scientific approaches to handle the systemic complexity of real world situations. For an early programmatic statement see

Weaver's (1948) concept of organized complexity, for an account of the inherent problems in analysing/controlling/designing social systems (see Luhmann 1984, 1997).

- (2) The failure to deal with future states of real-world systems. Design is involved in proposing the new, which, by definition, is not predictable. Early futures studies were still aimed at prediction, today there are projective and evolutionary approaches, which explore multiple futures and take the methods rather as learning devices than as forecasting tools.

This demands us to reconfigure and conjoin the two questions into one and ask:

How can design establish its own genuine research paradigm (independent from the sciences, the humanities and the arts) that is appropriate for dealing with purposeful change in ill-defined (therefore called "complex") real-world situations?

The discussion is embedded in ongoing debates about shifting modes of knowledge production in the sciences and in society at large. Nowotny *et al.* (2001) claim that science enters the "agora" and explicate "Mode-2" knowledge production, which is contextualized and which must be "socially robust" rather than "true". Science is increasingly involved in projects of socio-cultural and technological change, and this can be interpreted as "science approaching designerly ways of knowledge production" (Jonas and Meyer-Veden, 2004). Knowing *how* becomes equally important as knowing *that* (Polanyi, 1966). Therefore, I will step away from essentialist "theories of what" and have a closer look at process models or "theories of how" to design. Doing this from a *systemic and evolutionary perspective* leads to a cybernetic process model, which appears to be constitutive of any attempt at theory-building in design. Concepts such as "research through design" (Frayling, 1993, going back to Archer), or "project grounded research" (Findeli, 1997), or, although semantics-focussed, "science for design" (Krippendorff, 2005) offer promising starting points. But little has been done since to operationalize these concepts in a coherent model.

3. An anthropological assumption: designing as the essence of being human

The ability to design and to be conscious about this (i.e. to be retrospective and projective regarding one's own position in the surrounding world) seems to be the essential human characteristic, distinguishing us from the rest of the living world. The construction of models of the human position and ability of acting in relation to nature is one of the essential and unresolved challenges of modernity.

According to Latour (1998) and Jonas (2000) Boyle's *Invention of the Laboratory* and the scientific community as factory for the production of facts concerning nature adds to the transcendence of naturalised nature the immanence (feasibility) of socialised nature. Hobbes's *Invention of Leviathan* as representative of the unpredictable mass of citizens, seduced by their passions, adds to the immanence (mundane chaos) of the social the transcendence of a scientifically substantiated eternal order. It is thus, that the three paradoxical constitutional guarantees of modernity (Latour, 1998) arise:

- (1) even when we construct nature, it is as if we did not;
- (2) even when we do not construct society, it is as if we did; and
- (3) nature and society must remain absolutely separate; the work of purification must therefore remain separate from the mediation work.

Design cannot take part in the scientific endeavour of purification since it has to ignore the modern separation of nature and society. The conception and realization of projects necessarily includes natural and social components. Even Simon (1996, pp. 139-67), one of the protagonists of rational cognitive process models of designing argues that design, seen as a socio-cultural phenomenon, follows evolutionary patterns and has no final goals. The intentional transfer of system states into preferred ones (or: state 1 → state 2) opens up the hybrid field of the “Sciences of the artificial”. Management philosophy (Hayek, 1967) has argued that the separation of natural and artificial is insufficient. There are systems (Table I), which are the outcomes of human activities, but not the results of human purpose. And of all things it is these delicate hybrid systems, which are the actual subjects of management and design interventions; appropriate tools for these “semi-artificial” systems are still missing.

According to Rittel (1972), these “wicked problems” can only be overcome by opening up the closed algorithmic problem solving process (1st generation methods) and initiating a process of argumentation and negotiation among the stakeholders instead (2nd generation methods). In other words: he suggests a change from 1st order observation to 2nd order observation: not systems are observed, but systems observing systems (von Foerster, 1981). Under conditions of 2nd order observation, we have to account for the fact that the problem itself is not “given” but will be designed 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. Given this situation Rittel (Cross, 1984, p. 326) states slightly ironically:

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.

	Systems emerging without human activity	Systems as results of human activities
Systems which are results of human design/planning	–	Artificial (mainly technological + simple social) systems → “constructivist”
Systems which are not results of human design/planning	Natural systems (solar system, crystals, organisms)	Complex social systems (family, economy, ethics, culture, ...) → “evolutionary”

Source: Hayek (1967) and Malik (2000, p. 158)

Table I.
The generation of systems by human design/activities

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.

Jones (1992) 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 her/himself observing the evolving artefact.

4. 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 Test – Operate – Test – Exit-scheme (TOTE-scheme) 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”. 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 (1985) argues, 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 attempts of outside observers to make sense of their observations. 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, p. 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 do not 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 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, applying it to mental and social systems as well. His theory provides more delicate instruments for 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 a powerful driver of human evolution and, eventually, learning.

5. Evolutionary thinking as the basis: recognition and explanation

A *Darwinian view* of natural and cultural processes and *design* is deliberately adopted here, since there is not the least evidence that socio-cultural processes as a whole follows a kind of plan or design. Not even complexification seems to be a general characteristic of evolution. The concept of evolution appears to be promising for the sake of theoretical support and methodological progress. Evolution theory relieves us from assuming an Intelligent Artificer at some mysterious point of origin. Utter undesignedness, pure chaos was the starting point, no more conditions, no foundations are required:

A designed thing, then, is either a living thing or a part of a living thing, or the artifact of a living thing, organized in any case in aid of this battle against disorder (Dennett, 1995, p. 69).

A good design theory, as a designed artefact, should be able to explain its own emergence. And so far, Darwinian thinking, in close combination with operational epistemology (von Foerster, 1981), provides the only descriptive model, which satisfies this self-referential requirement. Any other explanation would be either a vicious circle or an infinite regress.

The epistemic characteristic of design can be assumed as a learning process. This process can be considered as biologically 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. The history of biological evolution suggests similarities of the way the material world is structured and the way we think of it. 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. Evolutionary epistemologists (Campbell, 1960) 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 provides 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, or accidents, environmental changes, etc.) 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. Toulmin (2001) traces it back to the mid-seventeenth century and distinguishes rationality from reasonableness, the latter losing authority in the sciences. The path from recognition to explanation is continuous and circular, sometimes with dead ends. Language is too much locked in the “black&white” tradition for the beautiful transitory shades of “grey” between the poles (Table II).

The argument of naturalized epistemology appears in various forms. 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 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 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

Table II.
Recognition vs
explanation

Recognition (Erkennen)	Explanation (Erklären/Verstehen)
Networks, many causes	Linear cause – effect relations
Simultaneous (simul hoc)	Sequential (propter hoc)
Four Aristotelian causes considered	Only <i>causa efficiens</i> 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”

Source: Riedl (2000, pp. 53-5)

regarded as the design-related description of these concepts. It is this special unspecific (generic) pattern, which Cross (2001, p. 54) 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. This is not to deny that designers/planners/people are able to intentionally design and manufacture a new teapot, a new aircraft, or a new constitution. But these designs are temporal interventions into evolutionary processes. Design interventions are episodes in the process of evolution. Most of the results disappear, a few are integrated into the further process. Failures as well as successes become part of the socio-cultural archive of mankind. Variation – selection – re-stabilization form the basic pattern of development (Luhmann, 1997; Jonas, 2005).

6. Variation – selection – re-stabilization: the basic pattern of socio-cultural evolution and design

Autopoietic systems show a high independence from internal and external perturbations (negative feedback compensates for the irritations). Furthermore, 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) (Figure 1).

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 (Figure 2).

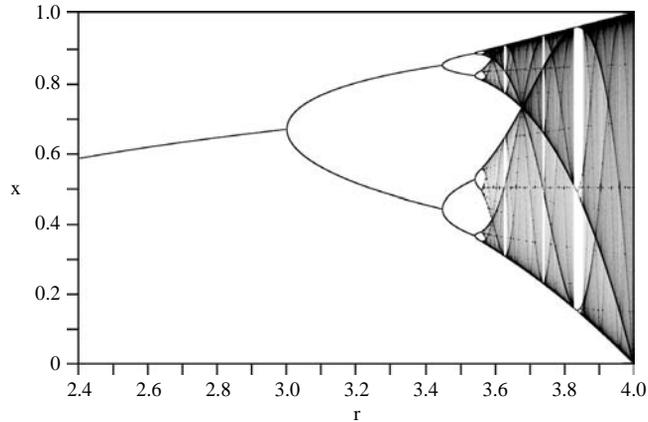


Figure 1.
Simple feedback processes

Notes: Simple feedback processes, as e.g. in the logistic equation $x_{n+1} = r x_n (1 - x_n)$ show the tendency to produce bifurcation cascades and deterministic chaos logistic equation (2007)

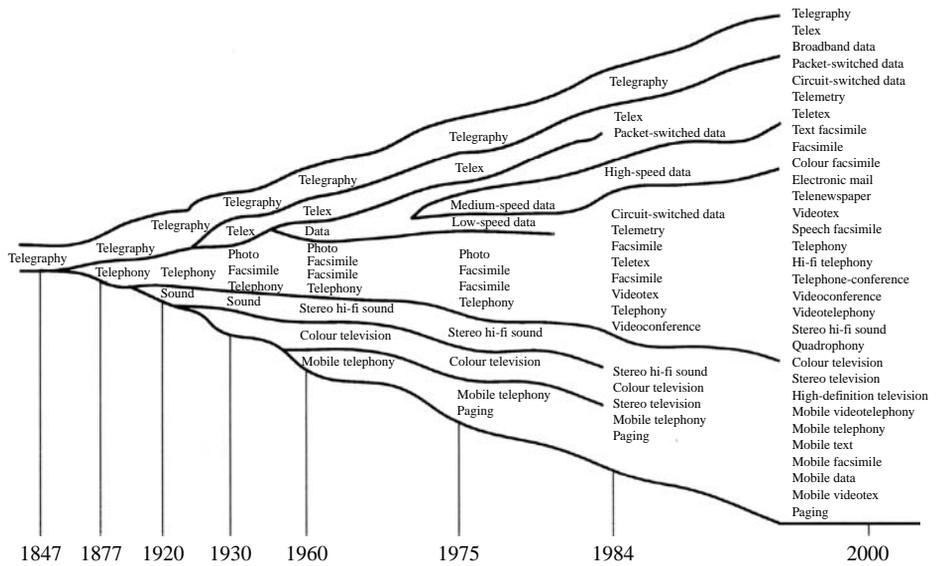


Figure 2.
Bifurcation patterns in the evolution of artefacts

Source: Graham and Marvin (1996, p.16)

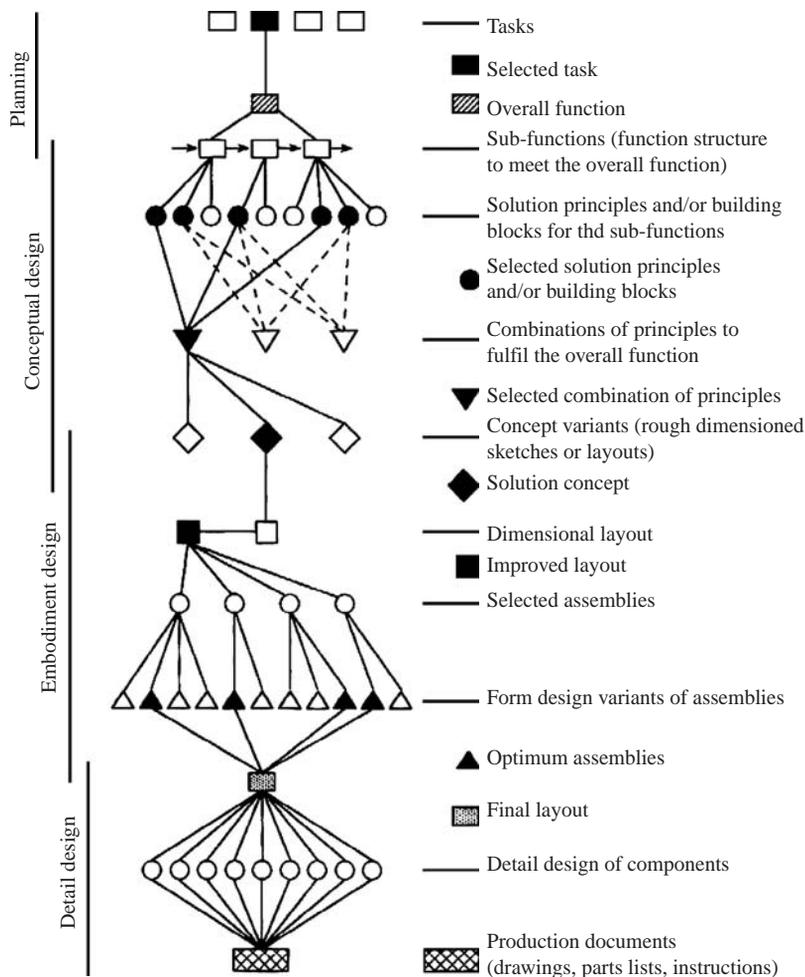
Hybs and Gero (1992) describe artefacts as entities struggling for the survival of the fittest in the hostile environment of the market; but the approach is still sub-complex.

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. Representations of design processes reveal these patterns too, which

may indicate some kind of similarity of ontogenetic and phylogenetic processes in designing (Figure 3). 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 (1972, pp. 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.



Source: Roozenburg and Eekels (1991, p.110)

Figure 3. Bifurcation cascades in the design process

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

These evident analogies in the processual patterns of natural and artefact evolution confirm the application of evolutionary concepts to the design of artefacts. No one-to-one analogies are sought; of course, variation in a meaning-based context is different from variation in organisms. It is not necessary to stick too closely to the biological concepts or to “translate” every feature of biological evolution to the socio-cultural field. 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.

Luhmann’s (1997) social theories are closely related to evolutionary epistemology. In his main oeuvre he 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”. Evolution theory thus explains the emergence of essential forms and substances from the accidental, relieving us of attributing the order of things to any 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 (Figure 4).

The three separated processual components of evolution can be related to the constituent components of society, conceived as a communicative system (Luhmann, 1997):

- (1) *Variation*. Varies the elements of the systems, i.e. communications. Variation means deviating, unexpected, surprising communication. It may simply be questioning or rejecting expectations of meaning. Variation produces raw material and provides further communicative connections with wider varieties of meaning than before. In design this means new artefacts, conceived as materialized communication.
- (2) *Selection*. Relates to the structures of the system. Structures determine the creation and use of expectations that determine communication processes. 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. In design this may be phenomena such as fashion, taste, etc.

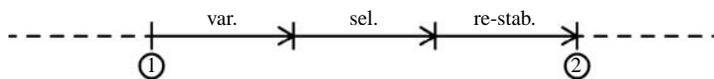


Figure 4.

Note: This figure represents variation - selection - re-stabilization as the basic pattern of socio-cultural evolution, transferring a system from state 1 → state 2

- (3) *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 or archive. In design this is the long-term viability of an artifact, in a functional as well as in a semantic sense.

There is the relation to Langrish's (2004) memetic concept of recipemes, selectemes, explanemes. And, more pragmatically, to Sanders (2006), who refers to the concept of usable/desirable/useful. She argues that we are quite good in designing usability, make progress in designing desirability, and are still weak in designing usefulness. I agree with her diagnosis, but – before the evolutionary background – I am highly sceptical as to substantial progress regarding desirability or even usefulness (Table III).

7. A generic design process model: designing as a learning process within the overall evolutionary pattern

An important step forward towards an integration and more precise differentiation of the concepts of design and evolution consists of the argument, that human designing comprises just the variation phase of socio-cultural evolution as introduced above. Designing, as a sometimes highly rational endeavour (bringing a man to the moon may include certain trial and error components, but cannot be considered as trial and error overall) is embedded in an overall trial and error process (Figure 5).

Although design activities desperately try to consider selection- and re-stabilization, they are necessarily de-coupled from these phases. There is no causal relation between variation – selection – re-stabilization. Bringing a man to the moon may turn out as the first step into the universe, or as a singular historical event of the second half of the twentieth century. So state 2 (the “preferred one”) should better be labelled state 2' leaving 2 for the actual future state, which cannot be determined. Design is about what is not (yet). This statement expresses the main epistemological problem/paradox the

	Luhmann (1997) (process steps)	Langrish (2004) (information units)	Sanders (2006) (success criteria)
Variety generation	Variation	Recipemes	Usable
Selective filtering	Selection	Selectemes	Desirable
Systemic re-stabil.	Re-stabilization	Explanemes	Useful

Table III. Evolutionary concepts with different authors

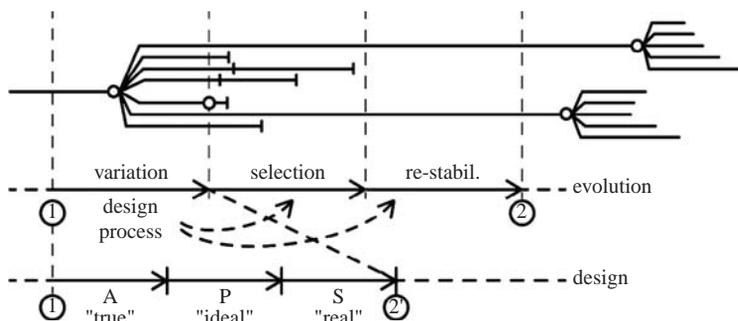


Figure 5. The conscious design process as part of the evolutionary trial and error process

discipline has to face in order to construct an own paradigm. Although designing happens now, it tries – by means of various methodological approaches – to include future developments. This issue has been addressed more philosophically by Nelson and Stolterman (2003), who argue that design is an inquiry into three domains of knowing: the true, the ideal and the real, with incompatible ways of reasoning. I have proposed the process model of ANALYSIS – PROJECTION – SYNTHESIS, which can be considered as a more pragmatic and operationalized version of the true/the ideal/the real (Jonas, 1996) (Figure 6).

The well-known circular design process models, as for example the one of the Institute of Design in Chicago (research – analysis – synthesis – realization), relate to a different origin. They seem to be adoptions of Kolb's (1984) "learning cycles". The latter, in turn, seems to be an adoption of the very basic cybernetic OODA (2007) model of the USAF (Figure 7).

If we combine the macro model of ANALYSIS → PROJECTION → SYNTHESIS (domains of knowing) and the micro model of research → analysis → synthesis → realization (the learning phases) we obtain a hypercyclic generic design process model (Hugentobler *et al.*, 2004) (Figure 8).

Hypercycles (Eigen and Schuster, 1979) are models of the basic process patterns at the transitory stage between chemical and biological evolution, in other words: explanations of the "origin of life" out of non-living material. The design argument becomes highly metaphoric here: hypercyclic processes produce autopoietic closure. Simple circular feedback cycles describe prototypical learning processes of autopoietic systems. They produce patterns of deterministic chaos and evolutionary development,

Figure 6.
ANALYSIS –
PROJECTION –
SYNTHESIS: the macro
cycle of the design process

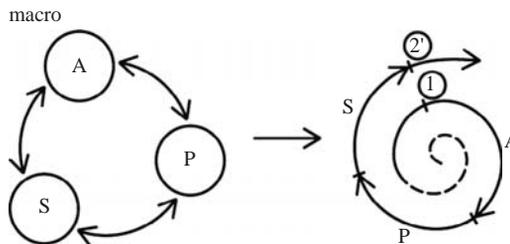
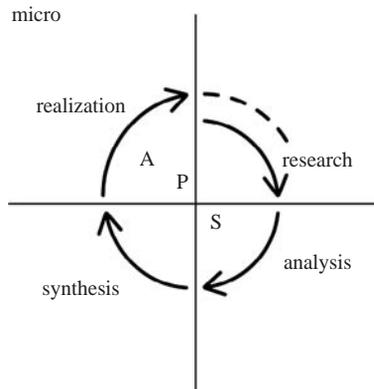


Figure 7.
Research – analysis –
synthesis – realization:
the micro cycle of the
design process



which supports the suggested link between cybernetic and evolutionary patterns. Natural and artificial evolution follows comparable processes. All this supports the concept of conscious design as necessarily embedded in evolutionary processes. Only the variation phase of artificial evolution is fully conscious and controllable. This is what we call design. That means most of the time the “watchmaker” is actually blind (Dawkins, 1986). He experiences some rare enlightened moments in an eternity of blindness (Table IV).

If we switch the mode from the metaphoric concept to operation, then we can interpret the hypercyclic scheme of the design process as a toolbox of three rows and four columns. Each of the 12 compartments that represent the complete process contains methods and tools for the respective process steps: for example, the ANALYSIS/SYNTHESIS compartment provides methods about “How to understand the situation as a whole? → worldviews” which can be, for example, systemic modelling techniques. If we assume ten methods per compartment and 12 process steps, then we arrive at 10^{12} different paths/processes. Each path is a legitimate roadmap of the design process, transferring state 1 → state 2'. The scheme is open for various “flavours” of design research: technological, cultural, user-centred, semantic, systemic, etc. It is just one possible model of a process, the validity of which has to be debated elsewhere.

The model allows individualized sequences/design processes. The distinction of design and research becomes fuzzy. The more one limits the inquiry to single domains of knowing or even to single process steps, the more it becomes possible and important to match the standards of scientific research. On the other hand, processes covering several boxes or even the whole process necessarily have to creatively deal with knowledge gaps (Jonas and Meyer-Veden, 2004).

8. Research through design through research: re-contextualizing the scientific paradigm

Success of designing depends on the variation phase of the evolutionary process. The following phases (selection, re-stabilization) are causally de-coupled. I.e. the quality of the design process is essential. Scientific contributions may improve the probability of successful design, to a certain degree. The field of HCI, as an increasingly design-related activity, is facing similar problems. Fallman (2005) tries to clarify the role of design in HCI research and argues that “it makes more sense to regard HCI as a design discipline rather than as a more traditional academic research discipline.” This is remarkable, and even a bit bizarre, since the design discipline on the other hand, is on

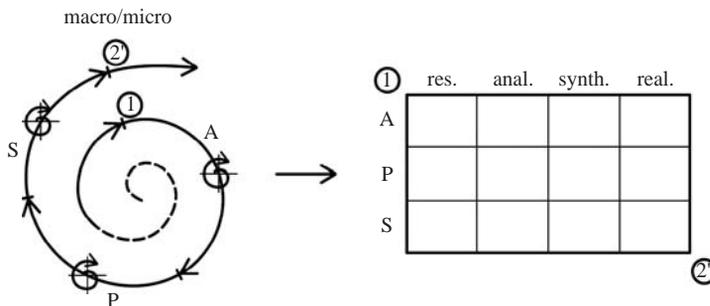


Figure 8.
The combination of macro- and micro cycle provides a generic, hypercyclic model of the design process, which can be linearized into a tabular scheme

the same road, but heading into the opposite direction, towards scientific research. Fallman distinguishes design and research in HCI as two poles of a continuum and coins the terms of “research-oriented design” and “design-oriented research” which can immediately be related to the present concepts of “research through design” and “design through research” (Table V).

Research within the “DRM-mindset” assumes that the “swampy lowlands” of uncertainty (Schön, 1983) will be subsequently replaced by well-grounded knowledge. But exclusively scientific research is unable to fully recognize the implications of acting in a space of imagination and projection, where design criteria only become apparent after the outcome has been designed. Therefore, the “knowledge base position” needs to be complemented by the “unknowledge base position” (Jonas *et al.*, 2005) or by the competencies to deal with not-knowing (Willke, 2002). It is not science as a method, but science as a guiding paradigm for design, which is being called into question. Examining design as processes in the course of socio-techno-cultural evolution will reveal more clearly what is impossible and will enable us to identify the stable islands of reliable knowledge. This view adopts the circular and reflective “trial & error” models of generative world appropriation, as put forward by Dewey (1986), von Foerster (1981), Glanville (1982), Schön (1983) and Swann (2002) and many others. Furthermore, the hierarchical separation of basic/applied/clinical research does not make sense in this conception of design. Basic research for real needs has to be closely related to real-world situations. I.e. basic research, in order to be basic, has to be embedded/applied in clinical situations.

The idea of research through design is based upon a generic structure of learning/designing, which has been derived from practice. Design process logic, according to the argument in this text, is a cybernetic logic of creating the objects of the world. Relevant design knowledge is not knowledge of the objects, but knowledge for the creation of the objects (Glanville, 2006). Every design process (more or less) follows this generic structure, making use of the various (scientific) methods provided for each of the steps. The inherent fuzziness of the process model is able to bridge the causality gaps occurring between the different, often incompatible, scientific contributions.

	Design ←	→ Research
Fallman (for HCI)	<i>Research-oriented design</i>	<i>Design-oriented Research</i>
	Design is driven by research within a larger design process, aiming at the real, by means of judgment and intuition, judged by the client	Research is driven by design within a larger research process, aiming at the true, by means of Analysis and logic, judged by academic peers.
Jonas (for design)	Research through design	Design through research
	Covering the whole situation/process, building design as an institution for human-centred innovation and supporting design as a discipline.	Focussing on isolated questions, producing knowledge for/about (?) design.

Table V.
Design and research in
HCI and design,
according to Fallman
(2005) and Jonas

The proposed paradigm of design research means that it is the generic design process and not the scientific process that guides design research. Other than Fallman, who just distinguishes the two approaches, I suggest a clear design-orientation:

The scientific paradigm has to be embedded into the design paradigm:

- research is guided through design process logic; and
- design is supported/driven by phases of scientific research and inquiry.

References

- Campbell, D.T. (1960), "Blind variation and selective retention in creative thought as in other knowledge processes", *Psychological Review*, Vol. 67, pp. 380-400.
- Cross, N. (1984), *Development in Design Methodology*, The Open University and John Wiley, London.
- Cross, N. (2001), "Designerly ways of knowing: design discipline versus design science", *Design Issues*, Vol. 17 No. 3, pp. 49-55.
- Dawkins, R. (1986), *The Blind Watchmaker*, W.W. Norton & Company, New York, NY.
- Dennett, D.C. (1995), *Darwin's Dangerous Idea. Evolution and the Meanings of Life*, Penguin Books, London.
- Dewey, J. (1986), *Logic: The Theory of Inquiry*, Southern Illinois University Press, Carbondale, IL.
- Eigen, M. and Schuster, P. (1979), *The Hypercycle. A Principle of Natural Self-Organization*, Springer-Verlag, Berlin.
- Fallman, D. (2005), "Why research-oriented design isn't design-oriented research", *Proceedings of Nordes: Nordic Design Research Conference, Copenhagen, Denmark, 29-31 May*.
- Findeli, A. (1997), "Rethinking design education for the 21st century: theoretical, methodological and ethical discussion", *Design Issues*, Vol. 17 No. 1, pp. 5-17.
- Findeli, A. and Bousbaki, R. (2005), "L'Éclipse de l'objet dans les Théories du Projet en Design", *Proceedings of EAD06*, available at: <http://ead06.hfk-bremen.de>
- Frayling, C. (1993), "Research in art and design", *Royal College of Art Research Papers*, Vol. 1 No. 1, pp. 1-5.
- Glanville, R. (1982), "Inside every white box there are two black boxes trying to get out", *Behavioral Science*, Vol. 27, pp. 1-11.
- Glanville, R. (2005), "Appropriate theory", paper presented at Futureground, DRS International Conference, Melbourne, November 2004.
- Glanville, R. (2006), "Construction and design", *Constructivist Foundations*, Vol. I No. 3.
- Graham, S. and Marvin, S. (1996), *Telecommunications and the City. Electronic Spaces, Urban Places*, Routledge, London.
- Hugentobler, H.K., Jonas, W. and Rahe, D. (2004), "Designing a methods platform for design and design research", paper presented at futureground, DRS International Conference, Melbourne, November.
- Hybs, I. and Gero, J.S. (1992), "An evolutionary process model of design", *Design Studies*, Vol. 13 No. 3, pp. 273-90.
- Jonas, W. (1996), "Systems thinking in industrial design", *Proceedings of System Dynamics '96, Cambridge, MA, 22-26 July*.
- Jonas, W. (2000), "The paradox endeavour to design a foundation for a groundless field", paper presented at International Conference on Design Education, Curtin University, Perth, Australia, December.

- Jonas, W. (2005), "Designing in the real world is complex anyway – so what? Systemic and evolutionary process models in design", paper presented at European Conference on Complex Systems Satellite Workshop: Embracing Complexity in Design, Paris, 17 November.
- Jonas, W. and Meyer-Veden, J. (2004), *Mind the Gap! – on Knowing and Not – Knowing in Design*, Hauschild-Verlag, Bremen.
- Jonas, W., Chow, R. and Verhaag, N. (2005), *Proceedings of EAD06*, available at: <http://ead06.hfk-bremen.de>
- Jones, J.C. (1992), *Design Methods. Seeds of Human Futures*, 2nd ed., Van Nostrand Reinhold/Wiley, New York, NY/London.
- Kolb, D.A. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, Prentice-Hall, Englewood Cliffs, NJ.
- Krippendorff, K. (2005), *The Semantic Turn. A New Foundation for Design*, Taylor&Francis Group, Boca Raton, FL.
- Langrish, J.Z. (2004), "Darwinian design: the memetic evolution of design ideas", *Design Issues*, Vol. 20 No. 4, pp. 4-19.
- Latour, B. (1998), *Wir sind nie modern gewesen. Versuch einer symmetrischen Anthropologie*, Fischer, Frankfurt/M., French original 1991.
- Logistic Equation (2007), available at: http://de.wikipedia.org/wiki/Logistische_Gleichung (accessed 3 January 2007).
- Luhmann, N. (1984), *Soziale Systeme*, Suhrkamp, Frankfurt/M..
- Luhmann, N. (1997), *Die Gesellschaft der Gesellschaft*, Suhrkamp, Frankfurt/M..
- Malik, F. (2000), *Systemisches Management, Evolution, Selbstorganisation*, Bern Stuttgart Wien, Verlag Paul Haupt, Aufl. 2. überarb.
- Maturana, H.R. (1985), *Erkennen: Die Organisation und Verkörperung von Wirklichkeit*, Braunschweig, Vieweg.
- Michl, J. (2001/2002), "Form follows what? The modernist notion of function as a carte blanche", available at: www.art-omma.org
- Miller, G.A., Galanter, E. and Pribram, K. (1960), *Plans and Structure of Behaviour*, Harvard Center for Cognitive Studies, New York, NY.
- Morgan, G. (1986), *Images of Organization*, Sage, Newbury Park, CA.
- Nelson, H.G. and Stolterman, E. (2003), *The Design Way. Intentional Change in an Unpredictable World*, Educational Technology Publications, Englewood Cliffs, CA.
- Nowotny, H., Scott, P. and Gibbons, M. (2001), *Re-Thinking Science. Knowledge and the Public in the Age of Uncertainty*, Polity Press, Cambridge.
- OODA (2007), available at: <http://de.wikipedia.org/wiki/OODA-Loop> (accessed 3 January 2007).
- Polanyi, M. (1966), *The Tacit Dimension*, Doubleday & Co., Garden City, NY.
- Riedl, R. (2000), *Strukturen der Komplexität. Eine Morphologie des Erkennens und Erklärens*, Berlin Heidelberg, Springer, New York, NY.
- Rittel, H.W.J. (1972), "Zur Planungskrise: Systemanalyse der 'ersten und zweiten Generation'", *Ders. Planen, Entwerfen, Design*, 1992 S (Original 1971/1972), pp. 37-58.
- Roozenburg, N.F.M. and Eekels, J. (1995), *Product Design: Fundamentals and Methods*, Wiley, Chichester.
- Sanders, E. (2006), "Design research in 2006", *Design Research Quarterly*, Vol. I No. 1.

- Schön, D.A. (1983), *The Reflective Practitioner. How Professionals Think in Action*, Basic Books, New York, NY.
- Simon, H.A. (1996), *The Sciences of the Artificial*, MIT Press, Cambridge, MA.
- Swann, C. (2002), "Action research and the practice of design", *Design Issues*, Vol. 18 No. 1, pp. 49-61.
- Toulmin, S. (2001), *Return to Reason*, Harvard University Press, Cambridge, MA.
- von Foerster, H. (1981), *Observing Systems*, Intersystem, Seaside, CA.
- von Hayek, F.A. (1967), "The results of human action but not of human design", in von Hayek, F.A. (Ed.), *Studies in Philosophy, Politics and Economics*, Chicago, IL.
- Weaver, W. (1948), "Science and complexity", *American Scientist*, Vol. 36, p. 536.
- Willke, H. (2002), *Dystopia. Studien zur Krisis des Wissens in der modernen Gesellschaft*, Suhrkamp, Frankfurt/M..

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Wolfgang Jonas was born in 1953, he studied naval architecture during 1971-1976 at the Technical University of Berlin, research on the computer-aided optimisation of streamlined shapes, PhD in 1983. During 1984-1987 consulting engineer for companies of the automobile industry and the German Standardisation Institute. Since 1988 teaching (CAD, industrial design) and research (system theory and design theory) at the University of Arts Berlin and at the University of Wuppertal. In 1994 lecturing qualification (Habilitation) in design theory. During 1994-2001 Professor for "process design" at the University of Art and Design Halle/Burg Giebichenstein. During 2001-2005 Professor for "design theory" at the University of the Arts Bremen. Since 2005 Professor for "system design" at the School of Art and Design, University of Kassel. Focus of interest: design theory as meta theory, design methods in a systemic perspective, scenario planning. Numerous publications on theoretical and practical aspects of designing, for example "Design - System - Theorie: Überlegungen zu einem systemtheoretischen Modell von Designtheorie" (1994) and "Mind the gap! - on knowing and not-knowing in Design" (2004), also publications on the history of naval architecture in Nordfriesland (1990) and on the aesthetics of modern ships (1991). Wolfgang Jonas can be contacted at: jonasw@uni-kassel.de