Observing Environments

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> Context • Society is faced with "wicked" problems of environmental sustainability, which are inherently multiperspectival, and there is a need for explicitly constructivist and perspectivist theories to address them. **> Problem** • However, different constructivist theories construe the environment in different ways. The aim of this paper is to clarify the conceptions of environment in constructivist approaches, and thereby to assist the sciences of complex systems and complex environmental problems. **> Method** • We describe the terms used for "the environment" in von Uexküll, Maturana & Varela, and Luhmann, and analyse how their conceptions of environment are connected to differences of perspective and observation. **> Results** • We show the need to distinguish between inside and outside perspectives on the environment, and identify two very different and complementary logics of observation, the logic of distinction and the logic of representation, in the three constructivist theories. **> Implications** • Luhmann's theory of social systems can be a helpful perspective on the wicked environmental problems of society if we consider carefully the theory's own blind spots: that it confines itself to systems of communication, and that it is based fully on the conception of observation as indication by means of distinction.
> Key words • **Umwelt, world, phenomenology, biosemiotics, autopoiesis, perspectivism, Peirce.**

1 Introduction

« 1 » Environments are pivotal to modern societies. As Niklas Luhmann wrote in *Ecological communication*: "Contemporary society feels itself affected in many different ways by the changes that it has produced in its own environment" (Luhmann 1989: 1), referring to consumption of non-replaceable resources, biodiversity loss, pathogen resistance, pollution, and over-population (and today we would add climate change to that list). Modern society not only changes its own environment – it compromises the quality of human life and undermines the conditions for its own continued existence. Since Gro Harlem Brundtland (1987), this problematic has been high on the political and scientific agenda. It is generally discussed within the framework of environmental sustainability, based on ideas such as sustained yield in forestry, ecosystem carrying capacity in ecology, and natural capital in economics, generalised to the consideration of global life support systems (Goodland 1995).

« 2 » The problems of environmental sustainability are "wicked problems" in the sense of Horst Rittel & Melvin Webber (1973). Wicked problems are complex, unique, dynamic problems that are never really solved. Different individuals and organisations disagree on what the problem is because they have different values and interests with regard to it and different perspectives on it. They therefore frame and formulate the problem differently. Bryan Norton emphasises:

> "For those frustrated with the lack of progress in many areas of environmental protection, Rittel & Webber's work suggested a powerful explanatory hypothesis: Complex environmental problems cannot be comprehended within any of the accepted disciplinary models available in academy or in discourses on public interest and policy. This failure is not a matter of inadequate practice, but a matter of principle." (Norton 2012: 449)

« 3 » With respect to wicked problems, we face an analytic void, Norton continues, and future analyses of complex environmental problems must be highly contextual.

« 4 » In other words, complex environmental problems are inherently multiperspectival. Each scientific and stakeholder perspective constructs its own immediate problem, which is but one aspect of the "really efficient" dynamic problem. Such complex problems therefore require transdisciplinary research cooperation that incorporates the dependence on context and perspective into an explicitly constructivist and perspectivist framework (cf. Alrøe & Noe 2011).

« 5 » However, the issue we want to address here is not on the level of different perspectives on environmental problems, but on the deeper foundational level of how "environment" is construed in different approaches to such problems. More specifically, we are interested in the construction of "the environment" in different constructivist approaches.

« 6 » The basic tenet of constructivism is the essential observer-dependency of observations and knowledge (as evident in Humberto Maturana's statement that "anything said is said by an observer" and Heinz von Foerster's basic idea that observers are necessarily involved in their observations and not neutral or outside, cf. Schmidt 2010). All constructivist approaches therefore share the intricate problem of the relation between observer and world – or system and environment. And any universal constructivist approach (*sensu* Luhmann 1995: 15) must be able to observe itself and its construction of "the environment."

« 7 » In this paper, we will thus turn constructivism on itself, observing the concept of environment in some important roots and proponents of constructivism. In particular, we will look at Jakob von Uexküll's biosemiotic theory of meaning, Humberto Maturana and Francisco Varela's biological theory of autopoiesis and cognition, and Luhmann's autopoietic theory of social systems.

« 8 » The three theories in focus are all constructivist in the sense that they take observer-dependency as a basic precondition. However, we have been elaborating a constructivist and perspectivist framework for research in complex agroecological systems and problems of environmental sustainability, based on these and related theories,[1] and through this work it has become clear to us that they contradict each other in important and quite fundamental ways. In particular, they have, as we shall see in the following, different conceptions of "environment," which are related to their conceptions of "observation" and "system."

« 9 » The aim of the paper is thus twofold: to clarify the concepts of environment in different constructivist approaches, and thereby to assist the sciences of complex systems and complex environmental problems.

« 10 » To meet this aim, we shall first describe how we go about observing environments, keeping track of different terminologies and perspectives, and give an overview of the concepts of environment (and related concepts) in von Uexküll, Maturana & Varela, and Luhmann, based on their own descriptions. On this basis, we then discuss the possible deeper conceptual differences in their conceptions of environment, focussing on differences that are important in relation to the foundation of constructivism and perspectivism. Finally, we draw some conclusions with regard to the application of constructivist theories on complex environmental problems.

2. Observing "the environment" in von Uexküll, Maturana & Varela, and Luhmann

2.1. How to observe environments

« 11 » In this section, we will give an overview of the concepts of environment and related concepts in von Uexküll, Maturana & Varela, and Luhmann, based on their own descriptions. But first we shall give a brief description of how we go about observing these environments.

« 12 » If you accept observer-dependency as a built-in precondition for scientific cognition and communication, you will be prepared for certain difficulties in observing the concepts of "environment" in different scientific approaches. The methodological challenge has three layers:

1 | the problems of different terminology (that the different approaches use different terms for "environment" and hold different meanings of the same terms),
2 | the connection of the terminological differences to deeper differences in perspective, and
3 | our need to clarify our own analytical perspective and make clear what concepts of observation and environment are used in the analyses and comparisons in order to discuss these differences.

« 13 » These methodological problems are no different from those encountered in other interdisciplinary work, but with the added twist that the research object is (also) the very concept of "a research object," since this (the research object) is a key aspect of the environment of a scientific system.

« 14 » As we have indicated, we will address this convoluted issue of observing environments by way of a perspectivist approach (cf. Alrøe and Noe 2011). This means that we will not only be looking at terminology in the form of different terms for "environment" and different meanings of the same terms, but also at the deeper differences in perspective that the terminological differences are connected to. We look at the differences in perspective in terms of elements such as domain and interests, type of examples, type of logic and model, and concepts and theories. With regard to our own analytical perspective, it builds on the very constructivist approaches that are scrutinized here, as well as other sources. In particular, our approach builds on Charles Sanders Peirce's theory of semiotics, and we shall utilize this comprehensive theory of meaning and representation in the critical analysis of the three constructivist approaches. This work will thus also have the added bonus that it will enable us to take a critical look at the perspectivist approach itself and the concepts of "observation," "system," and "environment" that are employed here.

« 15 » In accordance with this background, we will look first at von Uexküll's conception of environment, which was strongly influenced by the prominent Kantian philosophy of understanding that also influenced Peirce's semiotics. This philosophy, with its Copernican turn from "our cognition must conform to the objects" to "the objects must conform to our cognition" (Kant 1998: B xvi), is in many ways fundamental to constructivism (Glasersfeld 1995: 39) and an important root of perspectivism (Palmquist 1993). Von Uexküll's concept of environment, Umwelt, is now being widely used and debated, and this will help us elaborate a firm basis for the analyses. Furthermore, von Uexküll's work predates that of Maturana & Varela and Luhmann, and by proceeding in chronological order we will be better able to discuss how the approaches compare and differ.

2.2. Von Uexküll's Umwelt

« 16 » Von Uexküll considered himself Kantian in orientation, and he explicitly referred to Kant as a starting point for his work in biology. All reality is subjective appearance, he states, describing the solid ground that Kant prepared to support the edifice of the natural sciences. Kant placed the subject called man in opposition to its objects, and outlined the basic principles according to which objects are formed in our mind:

1| This framework combines autopoietic, cognitive, and semiotic theories (in line with Brier 2008) to model science as a cognitive system to complement the communicational aspects of science as a learning system (Alrøe 2000). This model is used to illuminate the inside/outside positions in research methodology, and to address the problems of handling values in science through reflexive objectivity (Alrøe & Kristensen 2002). In environmental ethics, the framework is used to elaborate a second-order cybernetic model of moral acting that establishes an ethical basis for sustainability and the precautionary principle from environmental politics (Alrøe & Kristensen 2003). In a later, fully perspectivist form, the framework is used to resolve the paradox of scientific expertise: that the growth of science leads to a fragmentation of scientific expertise. It also used to handle the ensuing problems of cross-disciplinary cooperation by exposing the perspectival structure of knowledge and science and introducing second-order perspectives (Alrøe & Noe 2011).

> "The task of biology is to expand the result of Kant's research along two lines: (1) To consider the role of our body, particularly our perceptual organs and the central nervous system and (2) to study the relationship of other subjects (animals) to their objects." (Uexküll 1973: 9f; translation from Thure von Uexküll 1992: 287)

« 17 » Uexküll elaborated on this task for the better part of his life, developing a theory of signs and meaning for the study of animal behaviour: "Behaviors are not mere movements or tropisms, but they consist of perception (Merken) and operation (Wirken); they are not mechanically regulated, but meaningfully organized." (Uexküll 1982: 26). In the course of this work he made important independent contributions, especially to the fields of (bio)semiotics and ethology, and also had some influence in philosophy, especially on theories of epistemology (e.g., Kull 1999, 2001; Harré 1990; Buchanan 2008; Stjernfelt 2011).

« 18 » From 1909, with the publication of *Umwelt und Innenwelt der Tiere*, through to the end of his life in 1944, von Uexküll focused his research on attempting to discern and give expression to what he called the Umwelten of animals, and which he alternately described as "phenomenal worlds," "self-worlds," and "subjective universes" (Buchanan 2008: 18).[2]

« 19 » "Each Umwelt forms a closed unit in itself, which is governed, in all its parts, by the meaning it has for the subject" (Uexküll 1982: 30) and "there are as many worlds as there are subjects" (Uexküll 1973: 70). For example, the stem of a blooming meadow flower can be a foot path to food in the Umwelt of an ant, an extraction point for watery sap to feed on and construct a protective cell in the Umwelt of a cicada larva, a morsel of fodder in the Umwelt of a cow, and a means of bodily ornamentation in a girl's Umwelt (Uexküll 1982: 29f).

« 20 » Von Uexküll uses different metaphors to convey how he understands these diverse animal (and human) environments. For instance, to glimpse the environments of the dwellers of a meadow, he envisages how we can blow, in fancy, a soap bubble around each creature to represent its own world, filled with the perceptions that it alone knows:

> "When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colorful features disappear; others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble we see the environment of the burrowing worm, of the butterfly, or of the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the *phenomenal world* or the *self-world* of the animal." (Uexküll 1992: 319)

« 21 » There are two important aspects of the concept of Umwelten here: that they are phenomenal worlds and that they are meaningful. Every animal, von Uexküll claims, is surrounded by a world in which the environment is perceived and known to this animal alone, and that may very well be invisible to other animals or humans. The soap bubble constitutes the limit of the animal's world, inside which things are significant and meaningful, and what lies beyond is hidden (Buchanan 2008: 23). Therefore we cannot easily understand the environment of other living organisms, be they animal or human. Von Uexküll presents the striking example of the female tick (*Ixodes ricinus*), which is blind and deaf. It has a very simple Umwelt consisting of sunrays, directing her up to the tip of a twig by the photosensitivity of her skin; the odour of butyric acid from mammal skin glands, which signals her to drop down; and a fine sense of temperature that leads her to the skin of the warm-blooded animal where she burrows deep in. "The external world (Welt) is as good as nonexistent, as are the general surroundings (Umgebung) of the organism. Both are theoretical references to contrast with the meaningful world of the Umwelt." (Buchanan 2008: 24)

« 22 » The precondition for there being limits for an organism to go beyond its own phenomenal world and enter into the Umwelten of other living organisms, is thus that the Umwelt is meaningful to the organism itself. Behaviour is not a mechanical process and animals are not "mere machines" [blosse Objekte], but subjects whose essential activity consists of perceiving and acting:

> "We thus unlock the gates that lead to other realms, for all that a subject perceives becomes his perceptual world [*Merkwelt*] and all that he does becomes his effector world [*Wirkwelt*]. Perceptual and effector worlds together form a closed unit, the *Umwelt*." (Uexküll 1992: 320.)

« 23 » In accordance with this, von Uexküll characterised his own approach to biology as "The theory of meaning" (Uexküll 1982), and came to be considered the founding father of biosemiotics (Sebeok 2001).

« 24 » Another pervasive metaphor that von Uexküll uses to express his theory of meaning is music: "The musical reference … is crucial to understanding how he interprets organisms as "tones" that resonate and harmonize with other things, both living and non-living." (Buchanan 2008: 8). For instance, he describes how an object can have different tones or qualities because an object in relation to a subject is a "meaning-carrier," and the object has different meanings in different contexts (Uexküll 1982: 27).

2.3. Maturana & Varela's autopoietic living systems

« 25 » Maturana & Varela's work can be characterised as "biology of cognition," and they are most widely known for their theory of autopoiesis as a fundamental characteristic of living systems. They define an autopoietic unity as

> "a network of processes of production, transformation and destruction of components that produces the components which: (i) through their interactions and transformations regenerate and realize the network of processes (relations) that produced them, and (ii) constitute it as a concrete unity in the space in which they (the components) exist." (Maturana & Varela 1980: 79)

2| The term Umwelt was invented by the Danish poet Jens Immanuel Baggesen in a German poem in 1800 (due to the necessities of the Homeric hexameter metric), and used thereon in both Germany (Umwelt) and Denmark (omverden). In Germany, it was originally used in the sense of 'surroundings;' after Uexküll, it came to be used mainly in his sense of 'the phenomenal world;' and since the 1970s the predominant meaning is that of 'the environment' in the sense of the environmental movement. Interestingly, 'Umwelt' has today been taken up in English language as a technical term within biosemiotics and related fields, in Uexküll's sense, though it is also employed in the two other senses. (Sutrop 2001, Chien 2007)

In other words,

> "one way to spotlight the specificity of autopoiesis is to think of it self-referentially as that organization which maintains the very organization itself as an invariant." (Varela 1991: 84)

« 26 » The focus on the autopoiesis and cognition of living systems in Maturana & Varela means that their concepts of environment are not as prominent and elaborated as von Uexküll's. They are, however, in many ways congruent with von Uexküll. In describing how their strand of biology of cognition is different from other strands, they "propose a way of seeing cognition not as a representation of the world 'out there,' but rather as an ongoing bringing forth of a world through the process of living itself" (Maturana & Varela 1998: 11). A key point, which is in line with von Uexküll, is the connection between action and experience: "this inseparability between a particular way of being and the way the world appears to us, tells us that *every act of knowing brings forth a world*" (ibid: 26).

« 27 » The paradoxicality of autopoiesis is that the living system must distinguish itself from its environment while at the same time maintaining its coupling, since it is this very environment that the organism arises from (Varela 1991: 85). In defining what it is as a unity, the organism at the same time defines what remains exterior to it, that is, its surrounding environment:

> "… this exteriorization can only be understood, so to speak, from the 'inside': the autopoietic unity *creates a perspective* from which the exterior is one which cannot be confused with the physical surroundings as they appear to us as observers." (Varela 1991: 85)

« 28 » The recognition of the importance of interpretation and significance as seen from the point of view of the living system is similar to von Uexküll's theory of meaning (though Maturana & Varela apparently did not know of his work). And it leads to a clearly perspectivist distinction that is stated as a key point that may seem obvious, but that has deep ramifications:

> "I mean the important distinction between the environment *of* the living system as it appears to an observer and without reference to the autonomous unity – which we shall call hereafter simply the *environment* – and the environment *for* the system which is defined in the same movement that gave rise to its identity and that only exists in that mutual definition – hereinafter the system's *world*." (Varela 1991: 85)

« 29 » In other words, the situatedness of a cognitive entity means that it has – by definition – a perspective, and that it relates to its environment in relation to the perspective established by the agent itself (Varela 1991: 99).

« 30 » The concept of environment is discussed by Maturana & Varela in relation to the two-way fit between organism and environment. This is what they refer to as a structural congruence between organism and environment, which is the result of structural coupling:

> "In these interactions, the structure of the environment only triggers structural changes in the autopoietic unities (it does not specify or direct them), and vice versa for the environment. The result will be a history of mutual congruent structural changes as long as the autopoietic unity and its containing environment do not disintegrate: there will be a structural coupling." (Maturana & Varela 1998: 74f)

« 31 » This also means that two or more autopoietic units can undergo coupled structural changes when their interactions take on a recurrent or more stable nature, without losing their internal organization.

« 32 » In a separate publication, Maturana makes a more elaborate distinction between medium, niche, and environment from the viewpoint of an outside observer:

> "The basic operation that an observer performs in the praxis of living is the operation of distinction. In the operation of distinction an observer brings forth a unity (an entity, a whole) as well as the medium in which it is distinguished." (Maturana 1988: 6, viii)

« 33 » The *medium* of a unity is the containing background of distinctions with respect to which an observer distinguishes it. The medium includes both what Maturana calls the *environment* of a unity – that part of the background that is distinguished by the observer as surrounding the unity – and what he calls the *niche* of a unity – that part of the background that the observer conceives as interacting with the unity, and to which it is structurally coupled: "… a unity continuously realizes and specifies its niche by actually operating in its domain of perturbations while conserving adaptation in the medium." (Maturana 1988: 6, xiii)

« 34 » In other words, the niche does not exist independently of the unity, and it changes as the domain of interactions of the unity changes.

« 35 » That is to say, for an observer, the unity is distinguished from its medium, which can be separated into its niche, with which it interacts and couples, and its environment, which (merely) surrounds it.

2.4. Luhmann's autopoietic social systems

« 36 » Luhmann devoted his life to building a unified theory of modern society based on systems theory and the German tradition of social philosophy from Kant onwards. As for von Uexküll, the concept of meaning was central for Luhmann, who drew especially on the phenomenology of Edmund Husserl[3], and he considered meaning the basic concept of the social sciences (Luhmann 2006, 1990: 21ff).

« 37 » Luhmann distinguished four types of systems: machines, organisms, social systems, and psychic systems, of which only the latter two are characterised by their use of meaning (Luhmann 1995: 2–3). This is in sharp contrast to von Uexküll, for whom meaning was a key biological concept. Consequently Luhmann considers only psychic and, predominantly, social systems. These have evolved together, and at any time the

3| It would be interesting and relevant to take a deeper look at Luhmann's Husserlian perception of phenomenological method, and how this relates to the concept of environment, but that would take us too far astray for this paper. Here we will only note that Peirce regarded Husserl's (early) work as psychologistic in character in spite of Husserl's claim to the contrary; yet Peirce considered his own early work on categories a foundational work in phenomenology (Ransdell 1997). See also Søren Brier (2009) on the relation between Husserlian and Peircean phenomenology and constructivism.

one is the necessary environment for the other (Luhmann 1995: 59). For psychic and social systems, meaning becomes the form of the world and consequently overlaps the difference between system and environment:

> "Even the environment is given to them in the form of meaning, and their boundaries with the environment are boundaries constituted in meaning, thus referring within as well as without." (Luhmann 1995: 61)

Society is not composed of human beings, but persons cannot exist without social systems, nor social systems without persons.

« 38 » The basic aspect of social systems for Luhmann is communication. Social systems are communicative systems, and Luhmann took the fundamental process of Maturana & Varela's autopoiesis – the system's reproduction of its basic elements to preserve its own organisation – and applied it to social systems in the form of self-production of the communicative elements. Therefore, ecosystems are not systems according to Luhmann. Luhmann states that the usage of the concept of system in this way, as in the normal use of "ecosystem," produces considerable confusion. Based on the theory of social systems, not every interconnection is a system. A system exists only when an interconnection distinguishes itself from an environment. In this systems theoretical sense, the environment is not a system in itself, but something that is constituted by social systems that differentiate and define their own boundaries: "The 'unity' of the environment is nothing more than a correlate of the unity of the system since everything that is a unity for the system is defined by it as a unity" (Luhmann 1989: 6).

« 39 » The consequences of this interpretation can be reduced to two points: (1) Society as a system is not seen as a smaller unity within a larger one (the world), but as the difference of the system of society and environment (cf. Luhmann 1989: 6), (2) The idea of system elements must be changed from substances or individuals to self-referential operations of communication that can be produced only within the system and with the help of a network of the same operations (autopoiesis).

> "If these two points are accepted then 'society' signifies the all-encompassing social system of mutually referring communications. It originates through communicative acts alone and differentiates itself from an environment of other kinds of systems through the continual reproduction of communication by communication. In this way complexity is constituted through evolution." (Luhmann 1989: 7)

« 40 » According to Luhmann, there is no environment in itself. It exists only in relation to something else, like a system as seen by an outside observer or from an observing system that distinguishes itself from its environment (Krause 2005: 250).

> "All observation of the environment presumes the distinction of self-reference and other-reference, which can only be made in the system itself (where else?)" (Luhmann 1997: 92, own translation)[4]

3. Perspectives on the environment

3.1. Fields of observation

« 41 » It seems clear from the above observations of the "environments" of von Uexküll, Maturana & Varela, and Luhmann, that they are different in several ways. In this section we will summarize how they are different and analyse what is behind the observed differences.

« 42 » As described above, an important (though rather banal) difference between these three approaches is that they are not concerned with the same thing, their focus or field of observation is quite different. Von Uexküll focuses on behavioral biology and how behaviour is linked to the sense and effector organs of the organism. Maturana & Varela share the focus on biology, living organisms, and their cognition. But their emphasis is on neurophysiology and not ethology. To understand the importance of this difference, it is telling that whereas von Uexküll founded the "Institut für Umweltforschung" (at the University of Hamburg), Maturana, for most of his life, ran a research centre on the "Biology of Knowledge" (at the University of Chile). In other words, von Uexküll looked mainly at animal worlds, how they differ, and how they are constructed, while Maturana & Varela looked at the organism itself, the nature of life, and the biology of cognition.

« 43 » Luhmann, in contrast to the two others, focuses almost entirely on social systems, as one form of autopoietic system, which he distinguishes from the living systems of Maturana & Varela and from psychic systems of consciousness and thought. For Luhmann, social systems are strictly communicative systems, defining communication as the unity of the selection of information, message, and understanding.

« 44 » These differences in domain are important in understanding the deeper differences, and we will return to them in the following analyses.

3.2. Terminology of the environment

« 45 » Before we can analyse any deeper conceptual differences, however, we need to look at the immediate terminological differences. The three theories treated in this paper use different terms for the environment, though they, and their commentators, are not always entirely consistent in their usage. Some of the terms are also used in general language, but often in different senses, and there are also difficulties in translating the terms.

« 46 » In this section, we will try to clarify the terminology in order to make the deeper conceptual similarities and differences clearer. We shall briefly discuss what might be better and worse terms – realizing that the usage of terms is something that is decided in the community of scholars and stakeholders – and determine the terminology to be used in the remainder of the paper. Since von Uexküll's concepts are the most elaborate and debated, we will, again, start here.

« 47 » The terms "phenomenal world," "self-world," "subjective universe," "subjective world," and "semiotic world" have all been suggested as translations of von Uexküll's concept of Umwelt (Sutrop 2001). Others prefer "environmental world" or simply "environment" (Buchanan 2008).

4| "Alle Umweltbeobachtung setzt die Unterscheidung von Selbstreferenz und Fremdreferenz voraus, die nur im System selbst (wo denn sonst?) getroffen werden kann."

« 48 » The terms "subjective world" and "subjective universe" situate themselves in the context of the subjective-objective distinction, which can be misleading because the Umwelt, as a Kantian and semiotic concept, transcends that very distinction. To underline this point, the opposite term "objective world" is in fact used by Deely (2001) and others as a translation for von Uexküll's Umwelt, and this term will be even more prone to misunderstanding. Drawing on von Uexküll's soap bubble metaphor for Umwelt, we might use the term "subworld," which has been used in somewhat similar meanings in artificial intelligence (e.g., Nierenburg & Rasking 1987) and ethnography (e.g., Crosset and Beal 1997), but not, to our knowledge, within biosemiotics. The term "self-world" can lead the reader in the direction of the concept of Eigenwelt, or own-world, in existential psychotherapy. That is, the mode of relationship to one's self as one mode of world, in contrast to the world of fellows and the world around (May 1958).

« 49 » This leaves the term "phenomenal world" as the better alternative of the suggested translations of Umwelt, and one that corresponds well with Peircean semiotics and its Kantian roots.

« 50 » Probably due to the difficulty of translating Umwelt, some advocate maintaining the German term Umwelt as a technical term in English, in the philosophical meaning of "phenomenal world" (Sutrop 2001). This usage of Umwelt is well-established in the scholarly community of biosemiotics, and it has also been used in psychology as "the technical term for the subjectively meaningful surroundings of an individual group" (Graumann 1983: 647). But outside these communities, this use of Umwelt in English is, in our experience, prone to lack of understanding, misunderstanding, and confusion with the current usage of Umwelt in German. Moreover, the term Umwelt is also used in other meanings than the von Uexküllian in English (Sutrop 2001).

« 51 » Uexküll himself experienced similar problems in describing the relations between an animal and its Aussenwelt (external world), He distinguished between Umwelt and three other concepts (Sutrop 2001: 453): Umgebung (surroundings) is the area in nature where an animal can be observed; Wohnwelt (environment) is the sum of ecological factors that enables an animal to live in its Umgebung; Umwelt means that every animal has its own world with only such objects that are significant for that animal; Milieu refers to the external world in the sense that living subjects are formed by the world they live in. "Unfortunately, Uexküll writes, Umwelt is often used for Umgebung, Wohnwelt, and milieu as well" (Sutrop 2001: 453).

« 52 » Directly following the usage of von Uexküll, we could still use his concepts in German (and Danish), Umwelt (omverden) and Umgebung (omgivelser). The problem with that is that, at least in German, the term Umwelt is today used generally in connections with environmental problems, etc., whereas the more philosophical phenomenological understanding of the term in the tradition of von Uexküll is obsolete, according to Sutrop (2001) (but note Luhmann's use of Umwelt). In Danish, the general term used in connection with environmental problems is "miljø," corresponding to the french "milieu," and "omverden" is used von Uexküll's sense, but also in other senses.

« 53 » In English, following von Uexküll's German terms Umwelt and Umgebung, we could be tempted to use the common words "environment" and "surroundings" for these two concepts, bearing in mind that they are not used in their common, rather vague meaning, but in the more precise meaning indicated above. The strength of these everyday words is that they are understood by all; the weakness that they will often not be understood with the meaning intended.

« 54 » Moreover, as we have seen above, this usage of environment is exactly opposite that of Maturana & Varela, where "environment" is used in roughly the sense of Umgebung, and "world" in the sense of Umwelt.

« 55 » Luhmann only uses only one term, Umwelt (which is consistently translated as environment), to indicate either the system's own distinction of itself from its environment or an outside observer's distinction of the system from its environment (Krause 2005: 250).

« 56 » Summing up, we will, for sake of clarity, use the slightly cumbersome term *phenomenal world* in the sense of von Uexküll's Umwelt and the term *surrounding world* in the sense of Umgebung in the remainder of the paper. These terms have the benefit of being generally understandable and not as prone to misunderstanding as the common term "environment."

3.3. Point of view on the environment

« 57 » Having looked at the differences in terms of their field of observation and the terms used to describe the environment, we will now go into some deeper differences related to how they construe their perspectives on environment in terms of the point of view, or observational position, from where the environment is observed.

« 58 » The constructivist postulate is that "the environment as we perceive it is our invention" (Foerster 2003: 212). As we have seen above, Maturana & Varela very clearly distinguish between the phenomenal world, the environment *for* the living system,[5] and the environment *of* the living system as it appears to an observer. They consider the shifting between inside and outside perspectives a cornerstone of biology and the awareness of these shifts a key to understanding the nature of the relationship between autopoietic autonomous unities and their environment (Varela 1991: 85). Von Uexküll also worked with the system of signs of the human observer in opposition to the system of signs of the organism under observation (Uexküll T. 1992).

« 59 » We consider this distinction between inside and outside perspectives to be a basic premise of perspectivism (Alrøe & Noe 2011; Alrøe 2000). A similar distinction has been widely used in anthropology and other fields (where the distinction is pivotal to adequate understanding) under the somewhat odd names "emic" (inside) and "etic" (outside) viewpoints, from the linguistic distinction between phonemic and phonetic (Headland et al. 1990).

« 60 » Luhmann also very clearly operates with a perspectivist approach (though he does not call it that), laying out premises of observation of observation following Maturana & Varela and von Foerster's (1980,

5| Of course ticks and other animals do not speak of their world, so the inside perspective of animals is that envisaged by an observer.

2003) second-order cybernetics. In a striking formulation, he says that "… a system can only see what it can see. It cannot see what it cannot. Moreover, it cannot see that it cannot see this" (Luhmann 1989: 23).

« 61 » He describes the environment as a horizon, as the system-internal correlate of all references that extend beyond the system, and that can be pushed back by system operations. As an internal premise, the system's environment has no boundaries nor needs any:

> "The horizon always recedes when it is approached, but only in accordance with the system's own operations. It can never be pushed through or transcended, because it is not a boundary." (Luhmann 1989: 22)

« 62 » But when the system is observed by another system, this observing system can also observe the constraints that the observed system enforces on itself through its own mode of operation. It can observe the horizons of the observed system so that what they exclude becomes evident. Following Maturana, Luhmann calls this "second-order observation." This clarifies the mode of operation of the system/environment-relations in a kind of "second-order cybernetics":

> "At present, second-order cybernetics seems to be the place where the problems of the foundations of logic and epistemology can, at least, be handled if not 'solved'." (Luhmann 1989: 23)

« 63 » However, as we noted above, Luhmann uses one and the same term, Umwelt/environment, for both inside and outside perspectives on environment. Of course, any "outside perspective" by an observer of the system is also an inside perspective for that observer. But still, if we do not distinguish between the environment seen from within and the environment as seen from some other perspective, we have a meaningful difference that we are not able to communicate. Luhmann was also, or became, aware of this need, perhaps through reading von Uexküll. At least he refers to von Uexküll (1928, 1934), and mentions that in biology he showed an early awareness of the fact that the environment of an animal is not that which we would describe as its surroundings or milieu, and that we can see more (or perhaps fewer) and other things than those an animal can perceive and process:

> "This also means that one deals with a different environment depending on whether one has in mind an environment as defined by a system – that is, the external reference of a particular system – or whether one assumes the existence of an external observer whose environment includes the system as well as its environment. It is entirely possible that the external observer can see many more and quite different things that are not necessarily accessible to the system itself… Hence, two concepts of environment must be distinguished." (Luhmann 2006: 50–51)

« 64 » However, Luhmann never attached different terms to those two concepts of environment.[6] Maybe the reason for this is that since Luhmann deals strictly with communicative systems, he does not face the strong dual context of living systems, whereas the biologist constantly switches between the (outside) perspective of physico-chemical principles and properties and the (inside) perspective of interpretation and significance. In any case, compared to von Uexküll and Maturana & Varela, this seems to lead to some lack of clarity in Luhmann's use of the term "environment."

« 65 » We follow Maturana & Varela in making a clear distinction between the environment seen from within and without, and maintain that this is a key point in any explicit constructivist and perspectivist theory.

« 66 » Lack of clarity on this distinction leads to contradictions. According to von Uexküll, the complexity of the environment (Umwelt in the sense of phenomenological world) is conditioned on the complexity of the system – more complex organisms have more complex environments and the environment is always less complex than the system. Luhmann, on the other hand, often states that the environment is always more complex than the system (e.g., Luhmann 1995: 182, Krause 2005: 10).

« 67 » He argues that society is composed merely of communications and that the highly complex arrangement of individual macromolecules, individual cells, individual nervous systems, and individual psychic systems belongs to its environment. No society can bring about the "requisite variety" or corresponding degree of complexity for such an environment:

> "However complex its linguistic possibilities and however subtle the structure of its themes, society can never make possible communication about everything that occurs in its environment on all levels of system formation for all systems." (Luhmann 1995: 182)

« 68 » Here Luhmann is clearly using "environment" in the sense of "surrounding world" from the perspective of an outside observer, or maybe even an ideal outside observer, from where the world outside the system is obviously much more complex than the system. From an outside perspective the development of the complexity of the system can be discussed in relation to the complexity of the environment, and it is possible to speak of the system's indifference to its environment (or ignorance of the environment).

« 69 » As Luhmann states, a perspective cannot see what is beyond its observational horizon, and even though we can try to observe this horizon and what is beyond it from many other perspectives, we can never fully capture "the whole world." We believe that a basic implication of the fundamental observer-dependency of constructivism is that we need to be able to talk about that which we refer to beyond the observational horizons from any given perspective. Following the perspectivist tradition from Kant and the development into semiotics in Charles S. Peirce, we therefore add yet another perspective to the inside and outside perspectives, namely a transcendental perspective.[7]

6| The quote above is from a lecture held in 1991. In his large, later book on society we can find no indication that Luhmann followed his own call to distinguish between the environment as defined by the system itself and the environment of the system for an external observer (e.g., 1997: 60ff, 128ff, 1025).

7| We agree with Nöth (2011) that while Peircean semiotics cannot be considered a precursor of constructivism as such, it is concerned with some of the same key questions as (radical) constructivism and provides a framework that

Concepts of environment	Phenomenal world or Umwelt	Niche or adaptive world	Surrounding world	"External reality"	"The whole world"
perspective in	inside or first- order (emic)	outside or second-order (etic)		transcendental	
Von Uexküll	Umwelt	Wohnwelt	Umgebung		Die Welt
Maturana & Varela	world or environment *for* the system	environment or environment *of* the system			
Maturana (1988)		niche	environment		
Luhmann	environment/Umwelt	environment/Umwelt			Die Welt or Die Realität
Kant	phenomena or immanent objects			noumena or transcendent objects	Welt an sich
Peirce	immediate objects			dynamical objects	

Table 1: Concepts of environment from different points of view, showing the terms used by von Uexküll, Maturana & Varela, and Luhmann, and placing the concepts of Kant and Peirce in relation to them. Note: The terms used by Uexküll have not been translated here because there are so many alternative translations. However, the column headings can be considered translations of Uexküll's terms.

« 70 » According to Kant and Peirce, the phenomena or immediate objects that we experience refer to something beyond the horizon of the phenomenal world, to what Kant calls noumena or transcendent objects, the thing in itself, and Peirce calls dynamical or "really efficient" objects (Palmquist 1993: App. VIII, Alrøe & Noe 2011, Nöth 2011).[8]

> "We have to distinguish the Immediate Object, which is the Object as the Sign itself represents it, and whose Being is thus dependent upon the Representation of it in the Sign, from the Dynamical Object, which is the Reality which by some means contrives to determine the Sign to its Representation." (Peirce CP 4.536)

« 71 » Phenomena are immediately accessible to us, whereas dynamical objects can only be referred to. A consequence of this is the basic insight that in any first order perspective, we only have access to the environment in the form of our phenomenal world. In none of the three theories have we found concepts corresponding to these more advanced, we believe, constructivist and perspectivist concepts for the relation between the multitude of phenomenal worlds and the idea of a shared world. But as Brier (1999) notes, both von Foerster's and von Uexküll's theories still retain the idea of one Universe, the independent something that everything was evolved from, and Maturana and Varela (1980: 11) also work with a shared evolution on earth as a basic precondition.

« 72 » In a constructivist understanding, there is of course no "objective world" and no "god's eye view" from where to see "the world as it really is" or "the whole world." "The world" is the blind spot of all observation, according to Luhmann – that which one must presuppose in all observation. Instead of a real outer world, "reality" is a resistance in cognition. "Reality is that which you don't see, when you see it" (Krause 2005: 213; own translation).[9] In a more constructive sense, the world is a limit case, like the concept of truth in Peirce's philosophy, where truth is an ideal concept for that which we will eventually reach through continued inquiry.

« 73 » In Table 1, the three types of perspectives, inside, outside, and transcendental, are used to provide a basic structure for the different terms for environment that we have discussed above. The column headings in the table are the terms that we have chosen to use here for the different concepts of environment connected to the three types of perspectives. Below are the terms used for these concepts of environment used in the three different theories that have been treated above. Furthermore, the concepts of Kant and Peirce have been added to make clear how we see the connections between the concepts.

4. The observation of environments

4.1. Observation as distinction or representation

« 74 » Having looked at different points of view or observational positions on the environment in relation to the three theories, we now turn to the deeper differences in how they observe the environment. As we will show here, there are two very different logics of observation involved, which we characterize as distinction and representation.

« 75 » Luhmann takes a genuinely radical constructivist approach to cognition: cognition is only possible because it has no access to realities outside itself – because it

can advance constructivist and perspectivist approaches.

8| See Ransdell (2007) for an account of the difference between Kant's thing in itself and Peirce's dynamical object.

9| "Die Realität ist das, was man nicht erkennt, wenn man sie erkent."

is operationally closed – and the premise of a common world is replaced with a theory of observation of observing systems (Luhmann 1998: 164ff). In his theory of social systems, the system is defined as the difference between system and environment, and observation is basically an act of distinction (Luhmann 1995: 36, 1998: 167ff).[10] Based on the logic of distinction developed by George Spencer-Brown (2009) in his *Laws of form,* he formulates a general conception of observation as indication by means of distinction: "Observation is the unity of the difference between distinction and indication" (Krause 2005: 88, own translation)[11]. In this he builds on the biological autopoiesis theory, which also operates with Spencer-Brown's logic of distinction (Maturana & Varela 1998: 40), as elaborated in particular by Varela (1979).

« 76 » Von Uexküll is less explicit about the kind of logic behind his *Bedeutungslehre*. However, his theory can be classified as "general semiotics" (Uexküll T. 1992). In the field of biosemiotics he is considered one of the founders and ongoing sources of inspiration along with Charles S. Peirce (Hoffmeyer 1996; Emmeche 2001).

« 77 » Von Uexküll devoted himself to two tasks, how the representation of an "objective" external world can be derived from a subjective universe, and how animals act as sign receivers (Uexküll T. 1992):

> "While constructing our world the sensations of the mind become the properties of things, or, as one can also put it, the subjective qualities form the objective world. Replacing sensation or subjective quality with perceptual sign, one can say that the perceptual signs of our attention turn into perceptual cues of the world." (Uexküll 1973: 102; translation from Thure von Uexküll 1992: 292–293)

« 78 » Von Uexküll here makes a distinction between perceptual sign (Merkzeichen) and "perceptual cue" or "characteristic feature" (Merkmal), where each perceptual cue is a perceptual sign that is "transposed to the outside." In other words, whereas the perceptual sign is received as an ego-quality of a sensory cell within the subject, the perceptual cue lies outside in the space of the external world (Uexküll T. 1992). The expression "transposed to the outside" thus forms the same function as Peirce's idea that the immediate objects within the sign refer to dynamical or really efficient objects outside the sign.

« 79 » In this light, we can identify the basic logic in von Uexküll's work as a logic of representation similar to Peirce's semiotics. The system, the organism, is characterised in terms of meaning, and observation is basically an act of representation.[12]

« 80 » This difference between the logic of distinction and the logic of representation goes deep, and it goes across the difference between the fields of biology and sociology. Based on a perspectivist view, the approach to such differences between perspectives is to clarify how the perspectives are different, what consequences the differences have for the observations made, and how the perspectives can possible be used in a coordinated way (Alrøe & Noe 2011). Among those who have noted this marked difference (though we have not seen it characterised as a difference of logic), are for instance Tom Ziemke & Nöel Sharkey (2001: 734), who write that a common criticism of Maturana & Varela's theory of autopoiesis is its disregard for such concepts as representation and information.[13] Therefore, they conclude, many cognitive scientists, and certainly many researchers in semiotics, will probably prefer the theoretical framework of Uexküll, whose theories emphasize the central role of sign processes in all aspects of life.

« 81 » Along the same lines, Brier writes that even though the epistemological theory of Maturana & Varela is a kind of constructivism, it is based on phenomenological mechanicism and not a theory of how signification is created: "Cybernetic and autopoietic theories fail to elucidate the phenomenological reality of perception and cognition – especially that of animals" (Brier 2008: 326).

« 82 » By building on the very general concept of observation defined as indication by means of a distinction, Luhmann's theory is confined to a form of binary logic.[14] In contrast, the (bio-)semiotic concept of observation from Peirce and von Uexküll (1982) is based on a richer conception of meaning and reference (where "indication" is just one of three basic types of sign: icons, indexes, and symbols[15]) and the genuinely triadic form of representation as the relation of sign, object, and interpretant, which cannot be reduced to binary logic (Peirce CP 3.483).

« 83 » Luhmann (2006) himself acknowledged the difference between the binary form of distinction and the triadic semiotics of Peirce. He suggested that semiotics could be "redrawn" in the form of distinction, where the sign is the difference between signifier and signified (Luhmann 2006: 45). We think (in line with Brier 2001) that this is not at all sufficient to replace the conceptually much richer Peircean conception of observation as representation. First of all it misses out the key concept of the interpretant, and second it does not capture the distinction between immediate and dynamical objects.

« 84 » On the other hand, one of the strengths of observation as distinction is the

10| Luhmann has stated that if he were to define an undeniable core in systems theory without which the whole system would disintegrate, it would consist of his thoughts on and sociological application of Spencer-Brown's calculus of form and theory about observation as operation (Andersen 2003).

11| "Beobachtung is die Einheit der Differenz von Unterscheidung und Bezeichnung."

12| Note that the Peircean notion of representation is very complex, general, and dynamic, and cannot be equated with the simplistic AI idea of representation as a direct mapping between internal symbols and external objects (Nöth 1997). The 'anti-representationalist' views of cognition (e.g., Varela 1991) are thus directed against a restricted and simplistic view of 'representation' and not the semiotic and triadic model of representation (Emmeche 2001).

13| They do note, however, that Varela et, Thompson & Rosch (1991) formulation of an enactive cognitive science is to a large extent compatible with an interactive view of representation.

14| Spencer-Brown himself showed that his "calculus of indications" was equivalent to Boolean algebra (Spencer-Brown 2009: 90ff).

15| Roughly, an index works by pointing at its object, an icon by resembling its object, and a symbol by way of a purely conventional rule or habit.

awareness of conditions for observation and unavoidable blind spots. The observer sees what she sees and does not see that she cannot see that which she cannot see. In other words, the distinction between observer and observed defines the blind spot of observation. All distinctions carry with them their own blind spot, since an indication always occurs within the scope of a distinction, which hence determines the observation (e.g., Andersen 2003). Luhmann is very aware of the need for a reflexive approach to observation, and the "blind spot" of observation is one of his key concepts.

« 85 » The two logics are incompatible: they exclude each other in the sense that they cannot be used in the same observation. On the other hand, observation as distinction shows things that observation as representation cannot, and vice versa. This means that the two are complementary in Niels Bohr's sense: they exclude each other from being applied at the same time, but only their conjunction gives the full understanding of the phenomena.

4.2. Observation and interaction

« 86 » An important consequence of Luhmann's definition of observation as distinction is that in this very abstract and general conception of observation there is no space for interaction.

> "Observations can only influence observations, can only transform distinctions into other distinctions, can, in other words, only process information; but not touch things in the environment – with the important, but very small exception of all that which involves structural couplings. Also for observing systems, there is on the level of their operations *no contact with the environment.*" (Luhmann 1997: 92; translation by the authors)[16]

16| "Beobachtungen können nur auf Beobachtungen einwirken, können nur Unterscheidungen in andere Unterscheidungen transformieren, können, mit anderen worten, nur Information verarbeiten; aber nicht Dinge der Umwelt berühren – mit der wichtigen, aber sehr schmalen Ausnahme all dessen, was über strukturelle Kopplungen involviert ist. Auch für beobachtende Systeme gibt es auf der Ebene ihres Operierens *keinen Umweltkontakt*." (Emphasis in original quote.)

« 87 » Although Luhmann uses biological autopoiesis theory as a main point of departure for his general systems theory, he does not adopt the conception of cognition originally connected with the theory (Alrøe 2000). Maturana & Varela (1998: 44–45) characterise cognition as effective action, an action that allows a living being to sustain its existence in a certain environment as it reproduces its world – no more, no less.

« 88 » In the biosemiotic tradition following von Uexküll, there is also a close connection between representation and interaction (Alrøe & Noe 2011). This is strongly expressed in his conception of the Umwelt as consisting of both Merkwelt and Wirkwelt (Uexküll 1992).

« 89 » In contrast to Maturana & Varela, Luhmann does not have a connection between cognition and action. For him, social systems are strictly communicative systems, and autopoiesis and cognition is the same kind of process.

> "The consequence, at least for social systems, is that autopoietic reproduction and the operations of self-description and self-observation that use the system/environment difference within the system cannot be separated." (Luhmann 1995: 167)

« 90 » There is only one kind of operation: communication based on observations as distinctions. The problem with Luhmann's radical abstraction is that it does not support the important aspects of our lives that are based on the connection between cognition and action, or between representation and interaction, such as learning and meaning.

> "… the tendency in cognitive science to abstraction, i.e., for factoring out situated perception and motor skills, misses the essence of cognitive intelligence which resides only in its embodiment." (Varela 1991: 96)

« 91 » Much communication is closely connected to a practice and a practical function in society (trade, punishment, consumption, construction, production, transport, sport, war, health, sex, food, science, etc.). If society is a social system and social systems are only communicative, then society has no body. This goes against the insight from Maturana & Varela and others that cognition is embodied. And if society has no body, it does not have a (non-communicative) environment either, consisting of ecosystems, climate, etc., which are key elements in today's wicked environmental problems.

« 92 » As we have shown, meaning is a key concept in von Uexküll, and representation entails meaning or significance for the organism:

> "…every action… that consists of perception and operation imprints its meaning on the meaningless object and thereby makes it into a subject-related meaning-carrier in the respective Umwelt." (Uexküll 1982: 31)

« 93 » The concept of meaning is very different in Luhmann. According to Brier (2001: 799), Luhmann does not really work with signification, since he, like Maturana & Varela, assumes meaning as granted. He does not work with a theoretical foundation of meaning from a phenomenological point of view other than that it is a surplus of interpretive possibilities and that he wants to leave behind all idea of a transcendental subject. Therefore Luhmann misses an important point in Uexküll's work and phenomenological theory, and he fails to see how important the biological level is for a theory of meaning.

« 94 » For Luhmann, meaning is the unity of the difference between the actual and the possible. In a "phenomenological description," he says that "meaning equips an actual experience or action with redundant possibilities." (Luhmann 1995: 60). He also says (somewhat vaguely!) that "it is better to avoid references to anything specific, since they always exclude something, and to introduce the concept of meaning as a concept 'devoid of difference' and intending itself along with" (Luhmann 1995: 59f), in the sense that: "meaning always refers to meaning and never reaches out of itself for something else" (Luhmann 1995: 62).

« 95 » In his article *Meaning as sociology's basic concept*, he states that "Meaning … overtaxes the potential of actual experience by including and presenting what is not directly experienced." (Luhmann 1990: 30). But this occurs only within an individual life of consciousness. Here the contents that are

actualized in perception or thought change ceaselessly from moment to moment, and meaning functions as a selection rule to select from other possibilities, and not – or only secondarily – as an actual content appearing in consciousness. In his little article *Complexity and meaning*, he further argues that "meaning is nothing but a way to experience and to handle enforced selectivity" (Luhmann 1990: 82).

« 96 » Luhmann says little about experiential learning, except on a rather abstract level: for example, "expectations that are willing to learn are stylized as cognitions. One is ready to change them if reality reveals other, unanticipated aspects" (Luhmann 1995: 320). But he does not describe how reality reveals. However, the concept of expectation (or habit, in Peirce's terms – belief is a habit of action) is important in understanding the differences in how learning and adaptation are perceived in the different perspectives.

« 97 » Luhmann considers science as a functional subsystem (among other subsystems) of a differentiated society. He states that the code of scientific truth and falsity is directed specifically toward a communicative processing of experience, i.e., of selections that are not attributed to the communicators themselves (Luhmann 1989: 77–78). However, this seems only to capture the communicational aspect of science that has to do with peer criticism – the cognitive aspect of science as experiential learning is left out (cf. Alrøe 2000).

« 98 » We believe that the notion of embodied learning is a key concept in understanding the relation between system and environment, both in science and in a more general context:[17]

> "Within this emerging framework, learning is conceived and acted out as an organic, embodied process based on the 'inseparability between a particular way of being and the way the world appears to us,' so that '*every act of knowing brings forth a world*'." (Horn & Wilburn 2005: 747, referring to Maturana & Varela 1998: 26)

17| More generally, adaptation can be seen as a form of learning in the sense of Gregory Bateson's logical types (or levels) of learning (Bateson, 1972: 279–308).

4.3. Observing complex environments

« 99 » In the previous section we highlighted some strengths and weaknesses of Luhmann's theory compared to Maturana & Varela and von Uexküll. Now we return to our starting point, the prospects for applying different constructivist theories to the wickedness of complex environmental problems. From our point of view, the strictly communicational structure of Luhmann's social systems theory and the logic of observation as distinction is a key weakness when observing complex environments. For instance, it seems to us that it counteracts the budding acknowledgement in economics that there is a need for alternatives to the dominating neo-classical economics, such as ecological economics, which set ecological boundaries to social and economic systems, and which in this way treat human societies more like organisms that depend on their environment.

« 100 » In this section we will, however, briefly underline some of the particular strengths that social systems theory brings to the bouquet of constructivist theories when it comes to addressing complex environmental problems, and illustrate this with some concrete examples from our own work.

« 101 » First of all, Luhmann treats *social* systems (including the systems of science) in a way that the two other theories are not capable of. And we do need theories of social systems to observe and handle the relations between complex systems and their complex environments – theories that are able to handle aspects such as self-reference, autopoiesis, and operational closure.

« 102 » In our own work, we have used Luhmann's theory in connection with complementary semiotic theories to observe and analyse the relation between systems and their environment for heterogeneous systems such as farming systems, which are technological and biological but also social systems (e.g., Noe & Alrøe 2006, 2012). The semiotic theories (Peirce, biosemiotics, actor-network theory) are strong in their ability to handle the heterogeneity of such systems, but lack the strong concepts of self-organization and operational closure that Luhmann's theory offers to handle these aspects, which are evidently there in our empirical investigations.

« 103 » Secondly, Luhmann (1989: 15ff) uses the concept of resonance to explain the basic condition for there being (autonomous) systems that would not exist as systems if they did not screen themselves off from environmental influences. They resonate with the environment only on the basis of their own frequencies (with an analogy from physics), and they only produce very selective interconnections in the form of couplings. Resonance with the environment is not something to be expected; on the contrary, it is improbable according to systems theory:

> "From the evolutionary point of view one can even say that sociocultural evolution is based on the premise that *society does not have to react to its environment* and that it would not have taken us where it has if it had proceeded differently." Luhmann (1989: 16)

« 104 » The concept of resonance assumes second-order cybernetics; it presupposes a reality that triggers no resonance at all within the system, and shows the inherent constraints on any observational effort (Luhmann 1989: 25). The observed system constructs the reality of its world through a recursive calculation of its calculations, and since this is the case on the level of living, neurophysiological, and conscious systems, Luhmann argues, it cannot be different for social systems either. It can draw no other conclusion than that this applies to its own observation too, but at the same time it can still see that what cannot be seen cannot be seen.

« 105 » In our own work, this is a key insight into the nature of communication in the social systems of food and science, which we have to deal with when making complex assessments of the effects of food systems on their environment,[18] and which forms an important basis for the development of a genuinely perspectivist methodology (e.g., Alrøe & Noe 2011).

« 106 » Third, there is the extensive theory of differentiation in social systems theory,

18| Reduction of complexity in the communication of assessments of effects of food systems on their environment, for instance through trust and visualisation, is one of three key challenges for the MultiTrust project.

which seems pivotal in addressing complex environmental problems:

> "…complex systems like societies are differentiated into subsystems that treat other social domains as their (socially internal) environment, i.e., differentiate themselves within the society, for example, as a legally ordered political system that can treat the economy, science, etc. as environment and thereby relieve itself of direct political responsibility for their operations. This differentiation theorem has far-reaching consequences." (Luhmann 1989: 19)

« 107 » It is just as suggestive as it is misleading to assume that "the" system reacts to "the" environment, even if this is only to "its" own idea of "the" environment, as Luhmann puts it. The idea of "the" environment of society is suddenly obviously dubious.

« 108 » In our work, we have used the theory of functional differentiation and structural couplings to analyse how decoupling due to the increasing differentiation of agriculture and food networks creates problems of sustainability, and as a new approach to look at sustainability solutions by way of recoupling and new forms of coupling (e.g., Noe & Alrøe 2012).

« 109 » Fourth, and equally important, is the notion of second-order observation applied to the social and scientific perspectives that are applied to solve complex problems. To analyse the problem of the exposure to ecological dangers with the necessary exactness, second-order cybernetics must be taken as the starting-point. In contrast to a naive faith in science, second-order observation together with its theoretical apparatus is not "objectively better" knowledge but only a different knowledge that takes itself for better (Luhmann 1989: 25).

« 110 » If the starting-point was an "objectively" given reality that was still full of surprises and unknown qualities then the only issue would be to improve science so that it could know the reality better. But there are many different systems in society, and since any "objective" approach would by definition be a singular perspective, the relations of the other systems to their environment would not be grasped sufficiently. Even science with its "better knowledge" often finds no resonance within society, because its "better" knowledge has no value in the environment of other systems or is at best a scientific theory for them (Luhmann 1989: 26).

« 111 » Any first-order observation of the environment is not in a position to grasp the problem of environmental sustainability:

> "We have to choose a second-order cybernetics as the point of departure. We have to see that what cannot be seen cannot be seen. Only then can we discover why it is so difficult for our society to react to the exposure to ecological dangers despite, and even because of, its numerous function systems." (Luhmann 1989: 26)

« 112 » Here Luhmann succinctly sums up the problem of observing complex environments and addressing complex environmental problems. The problem is paradoxical in the sense that any attempt to solve the problem with "doing things better," such as better science, better implementation, better communication, better decision processes, better access for stakeholder groups, etc., will fail or will even deepen the problem. This is because these solutions do not take into account the differentiation of observing systems in society, and the ensuing differentiation of the environments of observing systems. The problem is the acquisition of a different kind of insight:

> "In many ways modern society has opened up possibilities for observing and describing how its systems operate and under what conditions they observe their environment. The only drawback is that this observing of observing is not disciplined enough by self-observation. It appears as better knowledge. But in reality it is only a particular kind of observing of its own environment." (Luhmann 1989: 26–27)

« 113 » From our viewpoint, the problem Luhmann points out here is the lack of an adequate perspectivism (cf Alrøe & Noe 2011). We have applied this insight in some concrete examples of research methodology and policy by way of suggesting separate second-order observation processes (in the form of "polyocular communication") as necessary elements in inter- and transdisciplinary research on multifunctional agriculture and organic agriculture (Noe et al. 2008, Alrøe & Noe 2008). At present, we are striving to implement these insights in the form of multiperspectival methods in the transdisciplinary projects MultiTrust[19] – which will analyse and develop methods for multicriteria assessment of the effects of organic food systems – and HealthyGrowth[20] – which will make transnational analyses of successful mid-scale organic value chains in order to learn how they are able to combine volume and values.

« 114 » Communicating across specialised perspectives requires much dedication and reflexiveness, and, as Luhmann emphasises, such cross-perspectival work requires a certain modesty to avoid that some perspectives dominate others and mould them in their own image. In the words of Cilliers (2005):

> "The view from complexity argues for the necessity of modest positions. In order to open up the possibility of a better future we need to resist the arrogance of certainty and self-sufficient knowledge."

« 115 » The conception that every observation has a blind spot and that every perspective cannot see beyond its own horizon seems a particularly good starting point for accepting a modest approach.

Conclusion

« 116 » In this article we have discussed three different constructivist theories and their understanding of the relation between system and environment, with the dual purpose of developing a constructivist and perspectivist conception of environment and to help confront "wicked" complex environmental problems through constructivist systems approaches.

« 117 » The first step was to clarify the sense in which different terms for "the environment" were used, and how they relate to

19| MultiTrust runs 2011–2013 as part of the Organic RDD programme, which is coordinated by ICROFS and funded by the Danish Ministry of food (see http://www.multitrust.org).

20| HealthyGrowth will run 2013–2015 as part of Core Organic II, which is an ERA-NET funded by the European Commission's 7th Framework Programme.

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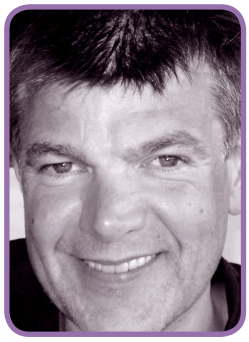

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inside and outside perspectives on environments, here labelled as "phenomenal worlds" and "surrounding worlds." The second step was to dig deeper and identify the different logics connected to their conceptions of observation, upon which the theories – being constructivist theories – are founded. We identified two very different logics: the logic of distinction (Spencer-Brown's *Laws of Form*) and the logic of representation (Peircean semiotics). These two logics are complementary in Niels Bohr's sense; that is, they exclude each other from being applied at the same time, but their conjunction gives a fuller understanding of what is being observed.

« 118 » Complex environmental problems are inherently multiperspectival, and we need theories for how to handle the many different perspectives on "the environment" and environmental sustainability. Constructivist theories are pivotal here, both because constructivism is the route to an adequate perspectivism that can handle multiple and complementary perspectives, and because the different varieties of what can broadly be called environmental research, can be sharpened by constructivist theories. However, as we have seen, there are not one but several different, and in some ways incompatible, constructivist approaches to the environment.

« 119 » Luhmann's theory of social systems is in many ways an eye-opening theory. It highlights crucial points for the sciences of complex systems and complex problems, such as sustainable food production and climate change mitigation, where society, social systems, and communication play decisive roles. Especially, his strong constructivist elaboration of observation of observation and the blind spots of observation can help overcome blind faith in "objective knowledge," and support the development of perspectivist approaches based on second-order observation. Perspectivism is as much realism as we can get.

« 120 » In order to be able to utilize the strength of Luhmann's very elaborate and stringent theory more widely, which we highly recommend, we need to consider carefully Luhmann's own call for a modest approach that is disciplined by self-observation. In particular, we need to consider the blind spots that are created by the fundamental assumptions of strictly communicative social systems and the logic of distinction. Only in this way can we ensure that this comprehensive and promising theory does not appear as "better knowledge" but as a helpful perspective on the wicked environmental problems of society, to be used in conjunction with perspectives based on embodied learning, semiotics, and the logic of representation.

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Open Peer Commentaries

on Hugo Alrøe & Egon Noe's "Observing Environments"

The Construction of Embodied Agency: The Other Side of the System–Environment Coin

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> Upshot • Complementary to Alrøe and Noe's discussion of constructivist notions of environment, world, etc., this commentary addresses the closely-related notion of agency in constructivist theories – in particular, the question of what would be required for artificial agency – and identifies open questions and fundamental disagreements among constructivist theorists.

« 1 » The target paper by Hugo Alrøe and Egon Noe provides an insightful exposition and discussion of different constructivist theorists' conception of the environment/world that systems/agents/subjects interact with. The nature of the systems that these theorists (Jakob von Uexküll, Humberto Maturana & Francisco Varela, and Niklas Luhmann) take as their unit of analysis varies significantly – from cells to organisms/animals to social systems – but they nevertheless share a basic commitment to viewing autonomy or autopoiesis as a key aspect of what constitutes such a "system" – or the relevant type of system – in the first place.

« 2 » For research in cognitive robotics or, more broadly, situated and embodied artificial intelligence (AI), which is concerned with the construction – in both the literal and the conceptual sense – of robotic systems that interact with and adapt to their environments relatively independent of human control, there is the additional question of what exactly would constitute an artificial agent/subject. Constructivist theories can make important contributions to understanding the issues involved, but the question can also, vice versa, be used to identify important differences between different constructivist theories and thus further the development of radical constructivism as such.

« 3 » The discussion in this commentary will focus on the theories of von Uexküll, Maturana, and Varela. This is because they are more directly relevant to the question of individual biological vs. robotic embodied agency and better-explored in this particular research context than Luhmann's work. As Alrøe and Noe point out in §§93–98, Luhmann does not address in sufficient detail the relevance of the biological level for a theory of meaning (§93) and therefore does not have much to say on the type of embodied learning/adaptation (§98) that is crucial to robotic systems' knowledge construction in sensorimotor interaction with the environment. On the other hand, as discussed in much detail by Kåhre (2009, 2010), Luhmann's work is of course highly relevant to understanding the social and societal significance of AI technology in a broader sense, including Internet search engines such as Google.

« 4 » Notions of artificial autonomous agency in situated/embodied AI research strongly emphasize sensorimotor interaction with the environment and independence from direct human control. Here are two representative examples:

> "By autonomous agent, I mean any embodied system designed to satisfy internal or external goals by its own actions while in continuous long-term interaction with the environment in which it is situated. The class of autonomous agents is thus a fairly broad one, encompassing at the very least all animals and autonomous robots." (Beer 1995)

> "An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future." (Franklin & Graesser 1997)

« 5 » Such definitions can of course be questioned from a number of perspectives (e.g., Sørensen & Ziemke 2007; Ziemke 2007a, 2007b, 2008). For example, one might ask exactly what is meant by "own" in "own actions" or "own agenda." Constructivist theories should be able to help clarify the issues involved.

« 6 » The works of von Uexküll, Maturana, and, in particular, Varela have had a significant influence on this type of AI research. For example, cognitive robotics and artificial life researchers have explicitly referred to von Uexküll, in particular his Umwelt concept (e.g., Uexküll 1973, 1957), in their discussions of how a robot's subjective inner world necessarily depends on its sensors and effectors (e.g., Brooks 1986, 1991; Prem 1997; Clark 1997; Ziemke 2001), i.e., its modes of interaction with the environment (for examples of concrete implementations see Macinnes & Di Paolo 2005; Capdepuy, Polani & Nehaniv 2007). But the influence also goes the other way: Varela, Thompson & Rosch (1991), for example,

used Rodney Brooks's behavior-based robotics approach (e.g., Brooks 1986, 1991) as an example/illustration of their enactive conception of embodied cognition.

« 7 » The organismic roots of the sensorimotor interaction between agent and environment, however, have been largely ignored in cognitive robotics research (cf. Ziemke 2008; Froese & Ziemke 2009; Ziemke & Lowe 2009). From a technological perspective, this is, of course, hardly surprising, given that practically all robots have sensors and motors, while no robot today is "living" (or autopoietic) in more than a metaphorical sense. From the perspectives of radical constructivism and embodied cognitive science (e.g., Ziemke, Zlatev & Frank 2007), on the other hand, the question is exactly how this lack of a living body effects/constrains the embodied cognitive capacities of robotic systems.

« 8 » Highly relevant to this question is what von Uexküll (1982) considered the "principal difference between the construction of a mechanism and a living organism," namely the fact that "the organs of living beings have an innate meaning quality, in contrast to the parts of machine; therefore they can only develop centrifugally." That means, organisms grow "outwards," i.e., the parts grow from the whole, whereas machines (at least in von Uexküll's days) are constructed centripetally, i.e., the parts are built first and then the whole is constructed from them. This (alleged) lack of "innate meaning qualities" raises the question of to what degree robots could be said to have a subjective/phenomenal Umwelt (cf. Emmeche 2001; Ziemke & Sharkey 2001). Naturally, von Uexküll himself was not familiar with modern computer and robotics technology. However, as we have discussed in more detail elsewhere (Ziemke & Sharkey 2001), the fact remains that even today's robots are still composed (centripetally) of mechanical parts, even if their adaptive – and to some degree self-organizing – control programs could be viewed as capable of some form of centrifugal development. Current research on adaptive/growing materials as well as on robots with living core components (such as a microbial metabolism, cf. Melhuish et al. 2006; Montebelli, Lowe & Ziemke in press) is bound to further blur the distinctions between organisms and machines that might have seemed clear-cut in von Uexküll's time.

« 9 » Alvaro Moreno, Arantza Etxeberria, and Jon Umerez characterize agential autonomy as implying that the internal organization of the system causes interactions with the environment and its monitoring according to internal needs. They therefore make a crucial distinction "between constitutive processes, which produce the identity and largely delimit what the system is, from interactive processes, which are not only side effects of the constitutive, but crucial to maintain the identity of the system, with the specific function of controlling the interaction with the environment" (Moreno, Etxeberria & Umerez 2008).

« 10 » While this view of the intertwined nature of constitutive and interactive processes seems to be much in line with Maturana & Varela's (1974, 1980) original view of the central role of autopoietic organization in the constitution of cognition, it is interesting to note, from the perspective of radical constructivism, that Maturana's and Varela's later interpretations actually seem to differ substantially on this point. Varela (1997) argues that the operational closure of nervous systems brings forth a specific mode of coherence, i.e. a cognitive identity that is embedded in the organism. Hence, he also characterizes the relation between constitutive and interactive processes as necessarily closely intertwined:

> "[T]he cognitive self is the manner in which the organism, through its own self-produced activity, becomes a distinct entity in space, but always coupled to its corresponding environment from which it remains nevertheless distinct. A distinct coherent self which, by the very same process of constituting itself, configures, an external world of perception and action." (Varela 1997: 83)

« 11 » Maturana (2004), on the other hand, argues that "[l]iving systems, like all systems, exist in two non-intersecting operational domains, the domain of the operation of their components (the domain of their composition), and the domain of their operation as totalities in the relational space in which they exist as such". He therefore argued that robots, despite their non-biological constitution, could very well be capable of self-consciousness if only they were made to interact with their environment the right way (through language in this case). He justified this argument as follows:

> "No doubt the manner of operating of a system as a totality arises from its internal structural dynamics through the operation of their components, but the character of what it does as a totality arises in its encounter with the medium in which it exists as a totality. … The same happens with robots. A robot is a robot of one kind or another according to how it arises in its operation as a totality in the relational space in which it exists as such." (Maturana 2004: 76)

« 12 » To briefly summarize: the fact that the cognitive robots used in modern situated/embodied AI research adapt/learn/self-organize (in a technical sense) in and through interaction with their environments, raises a number of interesting questions regarding the role of the living body in embodied cognition. This research is also highly interesting from the perspective of radical constructivism. This is because it raises the question of to what degree, using the above terms of Moreno, Etxeberria & Umerez (2008), the constitutive and interactive processes involved in agential autonomy can or cannot be decoupled. As the necessarily brief discussion above seems to indicate, it is far from clear to what degree constructivist theorists agree on this point.

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Multiple Environments!?

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> Upshot • The following remarks elaborate on the basic concepts of observation and environment. Some extensions are suggested, mainly from the perspective of Luhmann's theory of social systems. Especially, the concept of structural couplings is given more emphasis, not least because of its relevance to the sustainability debate.

« 1 » The debate on the role of constructivist approaches is of crucial relevance in clarifying benefits and difficulties and, especially, in the use of concepts such as "environment" and "observer" within such approaches. Of interest here is its contribution to epistemology, as well as that on the fundaments of social systems theory. Hugo Alrøe and Egon Noe's article is informative and helpful in separating several arguments that are from different scholars and in different discourses.

« 2 » At the core of the article are two central aspects to which some remarks could be added:

1 | the significance of the discussion, whether it is about philosophical intention or part of a sociological examination, and
2 | the use of the term "environment", either as a systems theory concept or as referring to ecological questions, including physical or biological assertions. I am going to formulate my remarks on this mainly on the Luhmann part of the article.

« 3 » So, firstly, let me address the level at which the argumentation is set. One important point is to do with the "subject" of the observing system. The important step taken by Niklas Luhmann was to change the perspective from individual (biological or social) agents to societal systems. These functional subsystems of not only society but also organizations operate "beside" those numerous empirical subjects. Therefore, a step from individual cognitive actors (e.g. organisms, living systems) to sub-systems of society was pursued. Such a shift in perspective has influences on the concept of observation and on the concept of "environment" as well. Most of the phenomena Luhmann is interested in are on a second-order observation level. Questions within such a perspective are about the consequences that arise when social systems organize observations within a certain framework (e.g., that of "morality" in Luhmann 2008). And it is an observer on a second-order level, then, that could analyze these consequences. In those cases, the interesting issues are the specific problems that arise because of the presence of other observing systems with their own suggestions for solutions to problems as well as for activities that hinder solutions. That seems to be the important step in a second-order perspective: to see what others could not see, and to analyze the restrictions found in such a situation.

« 4 » There is a severe problem in interpreting Luhmann's approaches. Before and after his "autopoietic turn" (somewhere around 1980), he used concepts and terms that are drawn from classical cybernetics and seem to have ontological residues. Later on, a firm reorientation to second-order cybernetics took place. However, his wording did not always look very different. Therefore, one has to be extremely careful when relying on citations from Luhmann's writings and has to consider explicitly the time of the publication of the text.

« 5 » It might be helpful to introduce another distinction: the distinction between a scientific observer and an observer without scientific aspirations. In the latter case, the usual mode is to use simplifications and "acting ontologies", mostly on a first-order observation level (Fuchs 2004 0.2.1). That seems to be exactly the level where communications about ecological crisis and sustainability problems are located.

« 6 » We have to mention a last point about the epistemology. We should not forget that the very concept "observation" shows a paradoxical basic structure (Luhmann 1992a). The above-mentioned simplifications used in ecological communication are examples of a "de-paradoxication" ("Entparadoxierung") in order to be able to make decisions and take responsibility for one's own actions (Luhmann 1989: 10). It might be that the question raised in §80 could be answered when considering such simplifications.

« 7 » The second set of remarks are about the use of the term "environment" in the controversy on variants of constructivism and, especially, on sociological systems theory. The authors present different approaches, whose subject matter range from physical facts to highly abstract epistemological schemes. In §49 the authors mention that Luhmann also uses only the term "environment" (without an index, for example) to cover these different meanings – and identify this as a source of confusion. A lack of clarity is noted by the authors because there is no differentiation between the "inside perspective" and the "outside perspective." Luhmann himself talked about the need to distinguish two concepts of "environment." There is also an important distinction by Humberto Maturana (1988), who talks about the general environment and the specific niche of systems.

« 8 » That brings us to the central statement about Luhmann's conceptualization. In §81 the authors clearly explicate the following: if society has – as a system only operating communications– no body, it has no (non-communicative) environment either. Are ecosystems, climate change, all today's wicked environmental problems, then nonexistent and not relevant from a society's viewpoint?

« 9 » But what, from such a perspective, are "the wicked environmental problems of society"? Those which are the content of communications taking place? And with the specification "wicked" is a specific distinction drawn or was a decision made to apply a specific reference framework? But by whom or by which system? On the basis of what distinction is the qualification as "wicked" justified? According to Horst Rittel's definition of wicked problems (Rittel & Webber 1973), they lack a clear solution strategy and change during their processing. That refers, again, to the social part of the system/environment relationship in contrast to the "material" characteristics of environmental problems. With respect to §§86f, it would be helpful to add a reference to a second type of fundamental structure in social systems. Besides the code as the fundamental distinction criteria, there are various programs that organize the operations of the systems. They likewise have to be considered (Luhmann 1992b: 228ff) because of their relevance to the observation process.

« 10 » In my opinion, a view on system/environment relationships and on the relevance of today's ecological problems might benefit from a deeper view of the concept of structural couplings. From Luhmann's writings on functional subsystems of society in the 1990s on, the term "structural coupling" became a more and more prominent element of the social systems theory repertoire.

« 11 » Structural couplings represent connections that are taken for granted by both systems that interact in order to guarantee a mutual preservation of existence. The concept was introduced to oppose the implication that systems merge together and build one united system. It also provides an alternative to interpreting relationships as causal relationships.

« 12 » With the concept of structural couplings, the claimed contradiction between the autonomy of systems and the interrelationships with and dependency on other systems is solved. One of the most convincing examples of structural couplings is the role of gravity in the ability of some organisms to move erect. In order to do so, some environmental conditions have to remain constant and, in this case, a structural coupling between organisms and their inorganic environment is established (Krause 2001: 162).

« 13 » An example relevant to sustainability discourse is a hunger crisis. Undoubtedly, such a diagnosis of a crisis is socially constructed – yes, but not on all the levels of which the problem is constituted. On the organic level, there is a rather strict coupling between resources in the (physical) environment and the functioning of the organism. Malfunctions, due to a lack of support with necessary foodstuff, energy for preparing meals, etc., cause severe function deficits. Signals and irritations are sent to the associated psychic systems and trigger thought processes and responses. According to Luhmann's suggestion, then, these signals have to be inserted into the stream of communications. Only at that point, eventually, does society come into play. Thus, a completely different type of analysis is applied compared with former theories, e.g., that of Pitirim Sorokin (1975). No direct causal connections are accepted as lasting from environmental (ecological) conditions to societal responses.

« 14 » Such distinctions, as introduced with the concept of structural couplings, could contribute to a better understanding of the contributions and claims of constructivist approaches. The environment is, from such a perspective, structured. According to Luhmann, the environment of a society consists primarily of psychic systems because they provide material for the stream of communications. The observation at that level could rely on the concept of meaning on both sides. On other levels, different observation schemes are necessary. Therefore, we find on different levels (interconnected by structural couplings) different modes of observation. Not different in the pure operation mode (distinction and designation) but different in the selection of issues considered.

« 15 » It has to be kept in mind that although Luhmann is not interested in ecological facts, simultaneously, he does not deny the existence of those facts. There are, in his words, other levels of reality that are definitely a source of irritations – however, not on the level of the primary, existential operating mode, the autopoiesis, the system. "Only in exceptional cases (i.e., on different levels of reality, irritated by environmental factors), can it… be set in motion." (Luhmann 1989: 15).

« 16 » But also at that level, circumstances can be imagined that lead to a destruction of the system, a breakdown of autopoiesis; that is, on the level of society, the extinction of the "participants" in the communication process.

« 17 » The authors state very clearly the necessity to differentiate several meanings of environment and find different co-notations in three representative constructivist approaches. A direct comparison is difficult because of the diverging epistemological frameworks that are utilized. What always has to be kept in mind is the point of reference, the reference system, laid down as the fundament from which the arguments are developed. The environment is, as a societal problem (beside others) indeed of higher complexity than the designated system, regardless of the constructivist relativisms and of the observer dependency. Various irritations from different sources reach the system and the responses, if activated, are not arbitrary and random but part of agreed social practices.

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The Complexity of Environment in Social Systems Theory

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> Upshot • We discuss the environmental terminology of Jakob von Uexküll in the context of Alrøe & Noe's reflections, and to examine more deeply the multiperspectivity that arises from a combination of von Uexküll's and Luhmann's systems theories. The complexity yielded by an unpacking of the term "environment" sheds light on the difficulties in finding common understandings for solving wicked problems.

Our perspective

« 1 » In general, we agree with Hugo Alrøe and Egon Noe's far-reaching reflections, which offer insights into the term "environment" and its meaning from diverse perspectives. Inspired by their thoughts, we would like to offer further perspectives based on the following questions:

1 | With respect to Jakob von Uexküll's diverse terminology on environment: Can other environments be distinguished in Niklas Luhmann's social systems theory?

2 | With respect to the system/environment distinction: How malleable is this relationship to redefinition and interpretation from multiple perspectives?

The meaning of different definitions of environment

« 2 » Alrøe and Noe introduce von Uexküll's environmental terminology. Synonymous to the term "Umwelt," von Uexküll uses "Wohnwelt," "self-world," "Umgebung," (i.e., general surroundings), "self-universe," and others. We discuss those terms, from the closest to the "self" to that which we later define as the "unknown" environment. In analyzing these terminologies in greater detail, it is obvious that they have distinct meanings. Therefore, our question is about the terminologies' specific definitions. In addition, we ask how relevant these terminologies might be to Luhmann's social systems theory, which operates with only one term for environment, i.e., for that which is distinct from a system.

« 3 » The term "Wohnwelt" is described as a list of ecological factors existing in an animal's system's "Umgebung" and that are relevant for its survival (§51). We would argue that "Wohnwelt" describes the smallest entity of the term "environment," and includes those factors most relevant for an organism's individual survival/existence, with a high potential for resonance effects or structural couplings. The autopoietic process of self-reproduction also includes input from this Wohnwelt. Of course, it is the system itself, through its operations, that decides what will be accepted from the environment (Wohnwelt in this case) in order to reproduce the system. In Luhmann's terms, the system determines meaningful structural couplings with the environment, which is the very narrow surrounding called "Wohnwelt."

« 4 » The term "self-world" (§47), which von Uexküll alternatively applied to "phenomenal" worlds, offers us two options for interpretation. For Luhmann, "self" is the difference between system and environment, and is mainly explained through Maturana & Varela's concept of autopoiesis. The self also includes the environment because the "self" constructs the environment. Thus, the distinction between system and environment might be described as a fluid rather than as a "precise" distinction. All phenomena that resonate with a living organism are part of its meaningful world (§23), i.e., the "self world."

« 5 » Is it correct to say that the self includes the environment? According to Luhmann, the system constitutes itself by distinguishing itself from its environment (i.e., self-constitution of the system, cf. Luhmann 1995: 9, 443, 456). The environment is everything but the self, the remainder of everything outside the system. However, we argue differently: if I distinguish myself from something, I have to know the other consciously; and based on that I make the distinction. It is, therefore, in a certain sense – maybe temporarily – part of myself.

« 6 » According to Luhmann, the term "eigen" (self) refers to what is reproduced in the system. "World" in combination with "eigen" implies something that we are able to survey, e.g., our personal/individual world (§48, see also §72: "the world is a limit case").

« 7 » "Umgebung" is described as the immediate environment. For an animal (system) this might be its hunting ground, or from the perspective of a soil microorganism (system) a soil aggregate. According to von Uexküll, the "self world" (§47) is what makes up the meaningful part of a system's general surroundings (Umgebung) (§21). Thus, the term "Umgebung" is clearly related to "environment."

« 8 » "Self-universe," which is another concept that is used by von Uexküll to describe the term "Umwelt," is a play on words. It represents some kind of hybrid understanding of "environment." While the "self" refers to something limited, the "universe" expands the view to something endless, interpreted as something that we are not able to gain an overview of, and is not known. It is impossible to distinguish between environment and system if the environment is not known. This "knowing" could mean: the system knows that it does not know about the environment, the system does not know what it knows, or that the system does not know what it does not know (Bammer & Smithson 2008).

« 9 » This analysis gives evidence for meaningful distinctions between different types of environment. This could open a space for revising Luhmann's proposed system/environment distinction to a system/environment/environment distinction. We offer opportunities to construct "environment," described as at least three types:

1 | The first type of environment contributes to the meaning of the system and provides knowledge and resources to reproduce the system (see §15 in this article). This type of environment entails phenomena that are conceivable (psychological) and communicable (social). We name this the system's "factual (or constituting) environment."

2 | The second type of environment is not relevant for the autopoietic process of the system at any given moment. There is neither communication nor structural coupling between system and environment. We name this the "potential (or stand-by position) environment." Stand-by position means that the environment already exists in the mind of a system, or – in a biological context – that there is something living or a consciousness, a "possibility space" for structural coupling.

3 | The third type of environment characterizes parts of the universe. These parts stand for an environment that is currently not known by a system. This does not exclude that it could one day become a potential or factual environment. From a system's perspective, it is what we name the "unknown environment." However, an observer is able to construct it.

« 10 » With these three types of environments, we argue in favor of a flexible application of the term "environment." The system always constructs one of these environments when making the system/ environment distinction. A system is able to construct the first two types in parallel. The observer is able to construct all three environments. The three environment types can, but must not, occur in their pure form. There might be time-space constellations leading to hybrids of the three environment types. We argue that constructs of different environments can exist, providing a meaning for the system. The distinction of different environments also proposes that the environment constructed by the system differs from the observer's construction of the system's environment. Interestingly, Luhmann only explains how the system reproduces itself and treats its environment as a black box. He argues: "it (the system) perceives its environment only restrictedly and categorically distorted"

(Luhmann 1986: 33; our translation; see also §68, "the system's indifference to its environment" and "ignorance of the environment").

The dynamics of the system/environment distinction

« 11 » In this chapter, we examine the system/environment distinction in greater detail. We discuss the "chicken vs. egg" problem applied to system and environment, the observer's perspectives on system/environment distinction, internal system distinctions, and the practical relevance of these dynamics when studying wicked problems.

« 12 » What Alrøe and Noe highlight with the paradox of autopoiesis is that the living system "must distinguish itself from its environment while at the same time maintaining its coupling, since it is the very environment that the organism arises from" (§26). Thus, the system emerges from its environment and vice versa, and the living system is part of the environment in which it emerges.

« 13 » Quoting Varela's "the exteriorization can only be understood… from the 'inside'" (Varela 1991: 85), the environment is solely constructed by the system (§27). This precedes consciousness of the environment and communication with it. Does it follow that the environment becomes part of the system, and thus the environment as an independent unit disappears?

« 14 » Luhmann (1995) follows this argumentation with reference to society as a whole. He defines society as the sum of all expectable communications. There is no communication outside the communication system of society. Society is a communicatively closed system. There is no communication with the environment because there is nobody who could answer. Thus, anyone giving an answer outside society becomes, by this, part of society (ibid: 402f.). He further argues that society is a comprehensive system that does not necessarily have an environment (ibid: 408f.).

« 15 » Coming back to societal groups, Luhmann describes several operations in which autopoietic systems and environments interrelate without the immediate consequence that the environment becomes part of the system. In contrast to society, using these operations, the environment keeps its distinction from the system:

1 | The system/environment distinction describes systems as environmentally open, which means that autopoietic systems are organizationally and operationally closed, while at the same time materially and energetically open (Luhmann 1982: 367).

2 | Resonance is "recursive – closed for reproduction and meanwhile open to irritations by the environment" (Luhmann 1986: 40; our translation). Resonance between system and environment is a precondition for structural coupling.

3 | Systems interact with their environment through diverse types of structural couplings. There is no loss of system independence. The structural couplings do not determine the status of the system. They merely supply the system with disturbances" (Luhmann 2002: 124).

4 | Interpenetration between systems describes that a system provides its own communication for the development of another system. Interpenetration "exists when this occurs reciprocally …" (Luhmann 1995: 213). Communication between two autopoietic systems, or evolutionary developments, demands interpenetration (ibid: 216).

« 16 » Cell division is a specific type of system/environment distinction (Maturana & Varela 1998). There could be three types of system/environment distinction. First, two systems serve each other as their environment. Second, each system creates a new and individual environment, which is separate from the other system. Third, both systems construct the same environment.

« 17 » What Maturana and Varela describe as the structural congruence between organism and environment (§29) is a characteristic that can also be found in systems e.g., agriculture. The agricultural system could serve as the environment from which non-organic and organic agriculture emerge. Agriculture is the environment for both systems. From another perspective, we could also argue that non-organic agriculture is the environment for an organic agriculture system, or vice versa. Both are autopoietic systems, able to reproduce themselves independently, and "can undergo coupled structural changes" (cf. §31). If the agent defines its environment (§29), this also determines potential communications, or structural couplings.

« 18 » Communication in an organic social system is not compatible with the non-organic system and vice versa. In both systems one will encounter different meanings and concepts of time and space, which might be the best explanation for the barrier between the systems. Luhmann's perspective is very helpful for understanding why organic agriculture is also seen as a social movement (cf. Hellmann 1996). It is a social system with limited significance in the system of big agro-business, because each follows its own binary code (in the organic system, e.g., ecology/non-ecology; in agro-business, profit/loss of capital), also described through their paradigms (Beus & Dunlap 1994).

« 19 » The inside-outside distinction (§§58ff) is an example of the relevance of different observer perspectives in understanding and interpreting wicked problems (§2). The system (an agent) itself constructs its own inside perspective, which is not directly observable by an observer. The observer is only able to re-construct the inner perspective of another agent through the interpretation of what the observer perceives from the outside, e.g., countenance of a person. For the observer, the observed system becomes his (the observer's) environment o_1. The system (agent) itself then makes the distinction through its own construction of an environment s_1. In a continuous feedback, the observer again observes the system as a new type of environment o_2 that is different to what preceded it. The complex multi-perspectivity is increased by the observer's own environment o_3, which could partly overlap with that of the agent's system.

« 20 » The observer's construct of system/environment distinctions of another system is based on the autopoietic capacities of his own system and not those of the observed person or system (cf. Luhmann 1984: 25). Thus, the observer constructs different operations and interprets their meaning differently than the observed.

« 21 » Systems differentiation is "nothing more than the repetition within systems of the difference between system and environment " (Luhmann 1995: 7), which means that further system/environment distinctions emerge in the system. This internal sys-

tem differentiation is described as a "process of increasing complexity" (ibid: 18), which is an autopoietic process of reproduction. Reproduction "offers possibilities for forming within the system a new system having its own system/environment difference …" (ibid: 258), which might survive longer than the former system.

« 22 » Applying different lenses to describe the system/environment distinction helps to understand complex systems and environments. To make this explicit, we study a farming system. We describe the first distinction between the farming system – defined as a social system or a biological system – and the agricultural industry as the environment. In a farming system we define animals as a system (binary code: to live/to die), while environment is all kinds of fodder. Of course animals ("non-rooted" organisms) communicate differently than grasses (meadows, pastures) ("rooted" organisms) do. They do not depend on each other, they follow different genetically defined communication procedures, and their reproduction is obviously different. Another distinction is that of a cow's stomach (system; binary code: to digest/not to digest) and an animal (environment); and finally there is a distinction between the stomach (environment) and a microorganism community (system; binary code is to duplicate, to divide/not to duplicate). We neither argue that these distinctions are "part (system) of the whole (environment)" nor that they follow a spatial concept. Both are perspectives of general systems theory, but not relevant for this commentary. What we provide are always independent system/environment distinctions. All named systems are autopoietic, exist through internal functions and operations, and are self referentially closed; and in the sense of Luhmann they are social (communicating), and also biological (living) systems.

Conclusion

« 23 » Regarding our first question, there is huge potential to reflect upon and integrate diverse system/environment distinctions. Von Uexküll's terminology offers several ways to describe environments, but they are not precise enough as he was not aware of the issue of the observer's construction of diverse system/environment distinctions. With respect to our second question, we argue that his interest was mainly in systems, system/environment distinctions, and system/environment interconnectedness, while the environment itself remained a complex (§66) black box. Von Uexküll provoked us to see various environments and reflect upon his perspective in the context of Luhmann's system theory. Applying multi-perspectivity to the system/environment distinction is of practical relevance when compromises between different system/environment realities are needed. In negotiation processes, these insights could help to make the roots of contradictory positions visible and to identify ways to better understand alter ego arguments. Of course there is the need to introduce the added value of these diverse constructs of environment in order to deal with wicked problems.

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Authors' Response: Systems, Environments, and the Body

Hugo F. Alrøe & Egon Noe

> Upshot • In our response we focus on how different types of systems are related from a constructivist perspective, and specifically on the relation between communicational social systems and embodied agency.

Introduction

« 1 » We are happy that our article "Observing Environments" seems to have struck a chord that resonates with other researchers, and which has resulted in three Open Peer Commentaries that offer extensions, complementary notions, and further perspectives.

« 2 » Tom Ziemke is concerned with the construction of robotic systems that interact with and adapt to their environments, focusing on the role of the body in situated and embodied cognition. In doing this, Ziemke finds little use for Niklas Luhmann's work since Luhmann does not address in sufficient detail the relevance of the biological level for a theory of meaning and therefore has little to say on embodied learning and adaptation.

« 3 » Karl-Heinz Simon takes an opposite approach, focusing mainly on Luhmann, even when discussing organisms, and thereby resolving the claimed contradiction between autonomy and dependency of systems with the concept of structural couplings.

« 4 » These two commentaries thus choose to either disregard Luhmann's work or disregard other constructivist theories. Thereby, they indirectly highlight the difficulties that we investigated in our article in discussing the environment across different constructivist theories.

« 5 » Bernhard Freyer & Rebecca Louise Paxton on the other hand, tackle the problem of using Luhmann's theory together with other constructivist theories, though, not surprisingly, in a less specific manner. Freyer & Paxton work in a field similar to ours, with agriculture, food, health, and wicked environmental problems. This calls for transdisciplinary research with multiple perspectives. Therefore they accept the necessity of working with different constructivist theories across the biological and social level.

« 6 » Together, the three commentaries suggest a need to look in more detail at how

different types of systems are related and specifically at the relation between social systems and embodied agency.

Types of systems and perspectives

« 7 » According to Luhmann (1995: 2), there are systems of different kinds and at different levels. He distinguishes four kinds of systems below the level of systems in general: social systems and psychic systems, which can be characterised by their use of meaning, and machines and organisms, which do not use meaning. Ziemke disagrees with Luhmann on the relevance of meaning for organisms and machines, and says that the distinctions between machines and organisms are becoming still more blurred due to developments in robotics and related areas. We agree, but a deeper question is what we may mean by "system" in a constructivist sense.

« 8 » In our article (§38), we discuss how Luhmann advises against other uses of "system" than a self-referential system that distinguishes itself from the environment - such as in the common use of "ecosystem" where ecological interdependencies are taken to designate a "system" (e.g., Luhmann 1989: 150). We appreciate the strength of the self-defining systems concept. But this does not make us refrain from questioning the "ontological status" of the systems we speak of.

« 9 » If we think about a farm as a system, we insist that it is a self-organising system (e.g., Noe & Alrøe 2006). But the farm is not merely a social system, or merely a biological system. A farm is a heterogeneous system that is biological, technological, and sociological at the same time. What we mean by this is not that the farm is some kind of "ontological hybrid" of different systems. What we mean is that a farm can be meaningfully observed from a range of specialised perspectives, including social systems theory. "System" is a perspectival concept.

« 10 » Given the above, the farm is a social system, an organisation, in the sense that it can be described in terms of communications and that it distinguishes itself from its environment. The farm is also a physical system, in the sense that it can be observed from the perspective of physics, chemistry, geology, etc., and be described in terms of energy, material flows, chemical processes, mechanical structures, etc. Here, the "system" is not very well defined and borders of the system have to be constructed from outside. The "farm as a physical system" thus cannot compete with the "farm as social system" on Luhmann's conditions for being a system.

« 11 » But we may also say that the farm is an organism, or a cyborg, in the sense that it can be described in terms of adaptation, senses, behaviour, etc., and that it has a body that matters. From this perspective, the farm is a self-organising system that maintains its own organisation and produces (some of) its own components in terms of recreating soil fertility, breeding stock animals, growing seeds for the next season, bringing up successors, reproducing knowledge and practices, etc. (Noe & Alrøe 2006). This perspective on farms can be found in organic and, especially, biodynamic agriculture (Paull 2006).

« 12 » Farms are different and different perspectives may not be equally fitting or fruitful for all farms. For some farms, such as a modern Danish pig farm enterprise that relies on a host of externally produced inputs and that has several employees, a management board, a wide range of advisors and suppliers that enter into farm operations, couplings to legal, economic and scientific systems, etc., the "farm as social system" perspective can be very fruitful for understanding how the farm works, and the "farm as organism" perspective less so. For other farms, such as a traditional subsistence farm that relies entirely on internally produced inputs and that has only the family working on it and no advisors or suppliers, it may be the other way around. But in neither case will one perspective be sufficient for understanding the empirical dynamics of the system.

Communicational systems and embodied cognition

« 13 » The farming system is just an example to indicate the issue we are trying to explicate. We need to talk about complex dynamical objects, such as "a farm," but we only have the immediate objects of different specialised perspectives at our disposal, such as "the farm as social system" and "the farm as organism" (cf. Alrøe & Noe 2011). Luhmann's social systems theory is not exempt from being a specialised perspective, even though it is "universal" in the sense that it is able to observe itself as a social system.

« 14 » Ziemke stated that in the case of embodied cognition and learning in robotics, Luhmann's social systems perspective does not have much to offer. Perhaps another example can illustrate the issue more directly. A scientific perspective, such as a specialised discipline like soil physics, can be observed as both a communicational and a cognitive system. As a social system, it establishes its own communicational organisation in the form of conferences, journals, peer review systems, email discussion lists, web pages, diagrammatic tools, etc. As a cognitive system, it creates its own organisation by establishing observation instruments, experimental facilities, research platforms, indicator systems, interactive models, computing equipment, etc. Embodied learning is an important aspect of science as a cognitive system, but not visible in science as a communicational social system.

« 15 » The same things can be said of a society. Society can be observed both as a social system that creates its own communication structures, and as an organism, or cyborg, that creates its own organization in terms of, e.g., transport infrastructures, cities, communication technologies, food and energy production. These different perspectives will enable us to observe different aspects of "society" as a dynamical object, and each have their blind spots. Aspects such as embodied cognition, learning and adaptation, embodied agency, sensorimotor skills, Merkwelt and Wirkwelt, monitoring systems, etc. may prove equally important to communication, functional differentiation, and structural coupling when addressing wicked environmental problems of modern societies.

Dependency of systems on their environment

« 16 » Is human society dependent on its environment or is it independent of the environment? Freyer and Paxton (§12ff) discuss this question in their commentary. The question is pressing when we talk about wicked environmental problems, and when ecological economy speaks of the depen-

dency of society on ecosystems and planetary boundaries for human influence.

« 17 » According to Simon (§§10–14), referring to Luhmann's writings, there are no direct causal connections leading from environmental conditions to societal responses. Instead the relationship is described in the form of structural couplings.

« 18 » However, the environment of society consists primarily of psychic systems, and Luhmann does not have much to say on the relation between a psychic system and the organism or body, nor on the relation to machines or technology. It is not clear how resonance and irritation can take place between different types of system. Therefore the dependency of society on the environment through structural couplings is, from an analytical viewpoint, rather indirect and unclear. Things such as feeling, value and empathy, which are important for taking action against environmental problems, can easily get lost through the series of structural couplings that link social communication and the body.

Conclusion

« 19 » The cases of farming systems, scientific disciplines, and embodied cognition in robotics challenge Luhmann's simple and rather conventional typology of systems. This is not the place to take up this challenge, but the commentaries encourage us to reiterate the recommendation in the target article. Luhmann's theory of communicational social systems is a helpful perspective on the wicked environmental problems of society, and we need to consider how best to apply the theory in conjunction with other perspectives such as the embodied learning perspective on society as an organism.

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