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Heterogeneous systems
- multifunctionality and multidisciplinary research

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Abstract
This paper concerns the application of system theory to heterogeneous systems, such as farming systems. Systems that in their organization and reproduction are physical, biological and technological as well as economical and social. Or, more precisely, systems that are neither of those things. The first problem is to gain a theoretical understanding of the empirical unity of farming systems. The second problem is to handle the different objects presented by different disciplinary perspectives on heterogeneous systems.

I. Background
Our empirical point of departure is research in farm enterprises and larger agricultural systems. The growing attention on the sustainability and, later, multi-functionality of agriculture and food production calls for more multidisciplinary and crossdisciplinary research. It has long been acknowledged that several disciplines are needed to understand farming systems. More recently, there is a growing awareness that a special effort is needed to integrate the findings of different disciplines when making decision, policies, etc. (see e.g. Noe and Alrøe 2006). It has proved very difficult to cooperate on research across disciplines, and consequently, the empirical problem or the matter of concern that initiates and motivates the arguments in this paper is how to do truly crossdisciplinary research on farming systems.

II. Semiotic foundation

In order to find a way to understand and cope with the more fundamental problems connected to the differentiation of disciplines, without ending in the trap of solipsism, we have turned to the philosophy of of Charles S. Peirce. A fundamental reason why it is so difficult to cooperate across disciplines is that each discipline has its own representation of the farming system as an object, and that it is not clear how these different objects can be combined. This problem can be analysed in a terms of Charles S. Peirce's semiotic distinction between dynamic and immediate object. According to Peirce, "A sign is something which stands to somebody for something in some respect or capacity." (Peirce, 1897, CP: 2.228) and "… it is necessary to distinguish the Immediate Object, or the Object as the Sign represents it, from the Dynamical Object, or really efficient but not immediately present object." (Peirce, 1908, CP: 8.343). The semiotic relation between the really efficient *dynamical object* and the *immediate object*, that represents the dynamical object is graphically illustrated below (Figure 1).

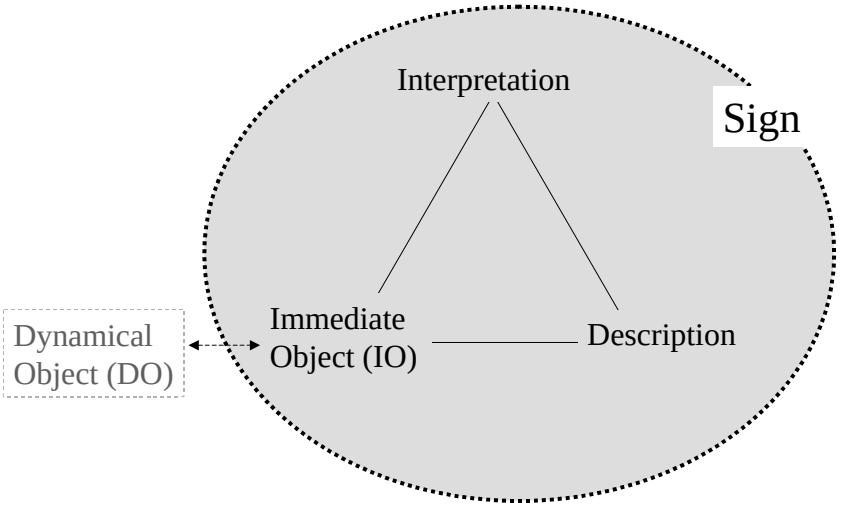

Figure 1: The relationship between the 'dynamical object' and the three elements of the sign, immediate object, interpretation (interpretant), and description (representamen), based on Peirce's semiotic.

An example that illustrates the elements of signification and the semiotic relation between the immediate and the dynamical object could be the sign "dairy cow". "Dairy cow" is the *description* (representamen, in Peircean terms) of the *immediate object* of a cow with respect to its "ability to produce milk." The immediate object has its ultimate reference point in the *dynamical object* of a cow as an "animal with a surplus of possible functions" such as meat, skin colour and ability to eat grass - reference points that could be the immediate objects of other signs that refer to the cow as a dynamical object. Finally, the *interpretation* of the sign could be "a cow producing milk for an income". If we take another example of signification in relation to a cow as dynamical object, the *description* "grazing cattle" would represent the *immediate object* of a cow with respect to its quality of "living from eating grass and other vegetation", again with an ultimate reference point in the *dynamical object* of a cow, and the *interpretation* of the sign could be "an animal that conserves meadows and fringes by keeping them free of seedlings and high vegetation".

According to Peirce, three analytically distinctive operations are performed within the signification process. One is the selection of an immediate object from the redundancy of possibilities pertaining to the dynamical object, the other is the assigning of a description, and the third assigning a logic linking the

quality of the immediate object with its function or use, the interpretation. Peirce uses the notion of habits of signs that assign a shared linguistic meaning. It is important to stress that, in Peirce's sense, there is no position from where we can observe the dynamical object as such; every perspective only adds to the number of immediate objects that refer to the dynamical object. This semiotic understanding lies beneath all the other arguments in this paper.

III. Approaches to understand a farm as a unity

Peirce helps us to understand the reason behind the problems with multidisciplinary research, but leaves us with the problem of the multitude of immediate objects. The next step is therefore how to deal with a farm as a dynamic object. A range of different integrating approaches and systems theories have been applied to observe and analyse a farm as an entity and thus determine the dynamic object. These approaches have each given valuable contributions to understanding farms, but still, we have found them insufficient for understanding the structures and dynamics of farm enterprises (Noe and Alrøe 2003). In a semiotic sense, each of them represent a farm as a different object from that of the others, and neither of those objects really resemble the structures and dynamics that we are confronted with in real farms.

This leaves us with the problem of how to delimit a farm as a system – what is included and what is not.

IV. Self-organization as a way to determine the farm as a dynamic object

Our first approach to solve the problem of delimiting the system was to acknowledge that a farming system observes and determines itself as an entity; and that they therefore should be represented as self-organizing systems or autopoietic systems (Noe and Alrøe 2006, 2003). This is a different approach to determining the farming system as a dynamic object.

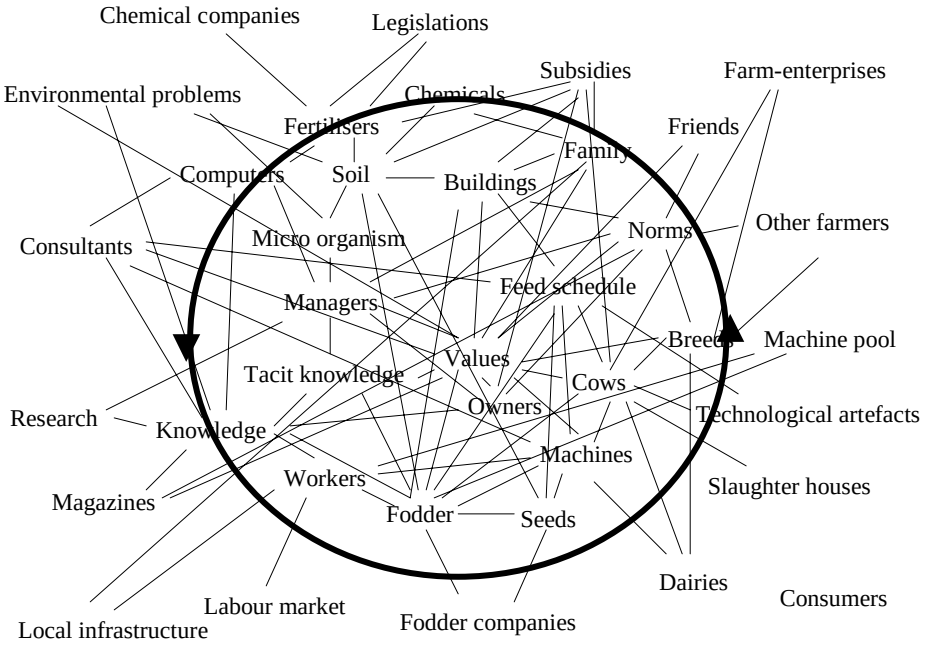

Figure 2: There needs to be a process self-reference to make the mobilisation of the farming network possible

Understanding farming systems as self-organizing systems is an important step toward an empirically satisfying theory for studying faming systems, but it also opened op a new theoretical question: How can the autopoietic or self-organizing nature of heterogeneous systems be understood?

V. How can the autopoietic or self-organizing nature of heterogeneous systems be understood?
The two main theories of autopoietic systems are Maturana & Varela's autopoietic theory of living organisms and Luhmann's theory of autopoietic, communicative social systems, which provide a strong theoretical basis for understanding self-organization. However, farms are neither biological organism nor social communicative systems, they are heterogeneous systems, and despite their very different fields of application, neither of these two theories is directed at heterogeneous systems. In these theories, the unity of heterogeneous systems can only be understood as structural couplings, but structural couplings are per definition couplings between autopoietic systems and thus cannot be the explanation of their autopoiesis. Our empirical experiences forces us to understand farming systems as self-organizing in all their heterogeneity, and we therefore need to complement our theoretical perspectives.

There are two distinct needs. The first is a need for at theoretical basis for understanding heterogeneity in an entity. In line with our fundamental semiotic view, we have brought in actor-network theory to expand the semantics to accommodate heterogeneity. The second is a need for a theoretical basis for understanding the kind of closedness that characterizes the self-organization of farm enterprises. To this end, we have employed Luhmann and the theory of logopoiesis to expand the kind of delimitations available for understanding the unity of farming systems.

VI. The heterogeneity of systems – an ANT perspective
From an objectivist approach it is impossible to clearly determine what belongs to the system and what belongs to its environment (cf. Figure 2). Actor-network theory expands, on one hand, the possibilities for a non-mechanistic approach to observe this and, on the other hand, the semiotic understanding of relations. This, in turn, opens a new way to understand the closedness of heterogeneous systems.

The focus of the development of ANT was to study the heterogeneous character of technology and scientific knowledge. As Law puts it:: "I simply want to note that actor-network theory may be understood as a semiotics of materiality. It takes the semiotic insight, that of the relationality of entities, the notion that they are produced in relations, and applies this ruthlessly to all materials - and not simply to those that are linguistic" (Law 1999, p 4).

If we approach a farm as an actor-network there are a lot of elements that are translated and enrolled into the objective of farming. There are the cows, various kinds of machines and technology, the fields, sunshine, rain, computers, various kinds of plants, labour, family labour, experience, skills and knowledge, values, goals, etc. depending on the heterogeneous strategy of the enterprise. One may easily realize how important it is to the results of the farming processes that all these interactions in the actor-network are balanced in accordance with the strategy of the network.

The perspective which we get from understanding farm enterprises from an ANT approach and the relationality of entities is that the entities enrolled get their forms and performances through the relations in which they are located (Law 1999, p 4). To explore this, a particular cow on one farm will eat grass from the field and on another farm stay in the stable and eat concentrate. And, theoretically, the same cow may

produce 12,000-kg milk in one system and 7,000-kg milk in another. The same kind of difference can be explored for the other entities enrolled such as wheat varieties, computers, etc.

To add to this complexity, the heterogeneous network of entities enrolled is not limited to the physical site of the farm. A lot of what we could call external entities are enrolled as, and mobilised as, actants into the farming processes: seeds, semen, advisors, capital, magazines, weather forecasts, fodder, food chains, colleagues, knowledge, labour, subsidies, etc. (see Figure 2). The kind of entities and actors that are enrolled or not enrolled into the network and how they are enrolled is characteristic of the enterprise, e.g. whether the commercial consultants or the consultants of the farmers' unions are enrolled and to what kind of performances they are enrolled.

It is also important to notice that actants enrolled in the network of the farm can be actor-networks themselves, e.g. in the shape of consultants offices, dairy companies, wholesalers, etc. organizing their own heterogeneous complexity. And that each of these is striving to translate the farm enterprises into their own network strategies by selling their products, etc.

ANT gives a platform for extending Luhmanns notion of communication and selection of meaning to all kinds of semiotic relations.

The relationary approach of ANT can be further radicalized with the help of Robert M. Pirsig's metaphysics of quality to understand relations as qualities that are prior to objects (Noe and Alrøe accepted).

VII. The closedness of systems – reproduction through selection of meaning and logopoiesis

Where ANT focuses on the heterogeneous openness of relations between the entities of the social, biological, and technical domains of the world, Luhmann takes the opposite position in his theory of social systems where he focuses on the operational closure necessary for any system to operate itself.

> "Autopoietic systems are systems that are defined as unities as networks of production of components that recursively, through their interactions, generate and realize the network that produces them and constitute, in the space in which they exist, the boundaries of the network as components that participate in the realization of the network" (Luhmann 1990, p 3).

Luhmann distinguishes between three kinds of autopoietic systems: biological systems operating in life, psychic systems operating in thoughts, and social systems operating in communication. Both psychic and social systems operate in meaning. None of these systems fits readily to heterogeneous social systems such as a farm enterprise. To pursue our efforts, we need to develop and add a category of heterogeneous social system to Luhmann's systems typology. In this paper we strive to do so from a Peircian semiotic perspective by way of broadening the understanding of communication to include heterogeneous relations. This is in line with Brier (2002), who suggests semioticizing Luhmann to include communication between different levels of autopoietic systems and not only the autopoietic language games of communication. At the end of the paper we will discuss a proposition to develop such a theory. We will first extract some of the central ideas of Luhmann's theory.

Luhmann's theory of autopoietic systems provides some fruitful notions for the study of farm-enterprises as self-organizing systems. The first step to understand the self-organizing process of a farm is the

selection of meaning. In Luhmann's terminology, meaning is linked to the fact of complexity that every operation enforces a selection:

> "Meaning is a representation of complexity. Meaning is not an image or a model of complexity used by a conscious or a social system, but simply a new and powerful form of coping with complexity under the unavoidable condition of enforced selectivity" (Luhmann 1990, p 84).

> "The phenomenon of meaning appears as a surplus of references to other possibilities of experience and actions. ……. Reference actualizes itself as the standpoint of reality. It refers however, not only to what is real (or presumably real), but also to what is possible (conditionally real) and what is negative (unreal, impossible). The totality of references presented by a meaningfully intended object offers more to hand that can in fact be actualized in any moment. Thus the form of meaning through its referential structure, *forces* the next step, to *selection*. This inevitability of selection enters into consciousness of meaning, and for social systems, into communication about what is meaningful (Luhmann 1995, p 60).

The selection of meaning is not to be confused with the notion of meaningfulness, but refers more to the semiotic notion that an element gets its identity through its relational position. We thereby understand Luhmann's use of meaning as semiotic, and his use of meaningfulness as normative.

Heterogeneous systems such as farm enterprises may be organized in numerous ways according to different goals and purposes, e.g. ecological or conventional production. The farm enterprise as a heterogeneous social system must select a meaning in the surplus of possibilities offered by each object that is mobilised into the system/network, in order to be operational at all. But the process of local summing up (with an ANT-term) into a coherent strategy is the unlikely situation. The network or system needs a kind of meaningfulness to make a situation of coherence possible and likely. According to Luhmann the production or reproduction of such system meaningfulness must be an internal process of the social system, in this case the farm enterprise. The encompassing world offers a surplus of meaningfulness, and the system has to select/develop its own in order to be operational in a coherent strategy.

The self-organization of social systems as autopoiesis is then a process of reducing complexity by selection of meaning. The selection of meaning must be a system-internal and self-referential operation by which the system draws its own operational boundaries. The farming styles studies are examples on how these operational boundaries can be studied (Ploeg 1994, Noe 1999). In these studies, farming systems are typologized with respect to the meaningfulness that they are organised around.

From an autopoietic understanding, the self-referential process of selection of meaning will, as a first step, be hidden to the system, because it is not a social system until a selection has been made. This corresponds to Mol's (1999) findings that the decisive moment of an actor-network will be moved to some facts from where there seems to be no choice. Only through reflexive (re-entry) processes can these choices be made open for observation to the system.

Another characteristic of an autopoietic system is that it has its own internal system rationality or schema at its disposal. Autopoietic systems are operationally closed systems. This means that the system must produce its own input for operation. E.g. the needle does not produce the feelings of pain while the person

who feels the pain does. The nerve cells are only transmitting impulses, and it is in the mind that this disturbance is translated into pain. So, it is the internal schema of the system and not the specific quality of the perturbation that defines how a system reacts to a certain perturbation.

> "Translated into the language of causality, this idea decrees that a system must control its effects on the environment by checking its repercussions upon itself if it wants to behave rationally. A system that controls its environment in the end control itself [note omitted]" (Luhmann 1995, p 475).

> "The environment is a world horizon that corresponds to the system's internal horizon. Therefore, a system's rationality cannot be clarified by referring to a superordinate, encompassing system" (Luhmann 1995, p 474).

The notion of self-reference also leads to a general understanding of observation, namely, that it is the internal complexity of the system that is limiting the capability of the system to observe itself and the capability to observe the encompassing world.

According to Noe and Alrøe (2003), the ontological understanding of a farm enterprise as a self-referential autopoietic system is widening the possibilities for observing and understanding the complexity of farm enterprises to e.g.: observe the rationality and values around which farm enterprises are organized; explore what kind of internal and external observations are involved in the management; and observe whom and what are involved in the management processes. All these aspects are adding to the exploration of farm management based on the inner system logic (Noe 1999).

The autopoietic metaphor for a farming system seems very useful to grasp the self-organizing identity of a farm enterprise (and for other enterprises as well), but the question remains how to understand the mode of autopoietic reproduction of the farming system. To observe the self-organizing processes of a farm only as a communicative system may not be sufficient to understand the very heterogeneous character of a farm. From the system theoretical angle a farm enterprise may be perceived as a structural coupling[1] between social, psychic, biological and technical systems, but Luhmann's theory leaves no suggestion to understand the autopoiesis of such mixed socio-technical systems:

> "Therefore, to cite an extreme case, no system unity can exist between mechanical and conscious operations, between chemical operations and those that communicate meaning. There are machines, chemical systems, living systems, conscious systems, and (social) systems that communicate via meaning: but no system unities encompass all these at once. A human being may appear to himself or to an observer as a unity, but he is not a system. … The living system is inaccessible to the psychic system; it must itch, hurt, or in some other way attract attention in order to stir another level of system information – the consciousness of the psychic system – into operation" (Luhmann 1995, p 39-40).

The above theories deliver many answers to the questions of how an enterprise is organised. However, they provide us with no answers to the question of why enterprises are organised. In biology there is a

[1] This is further discussed in Alrøe (2000, p. 71ff). Luhmann uses 'structural coupling' as a term for the interdependence between autopoietic systems at different (emergent) levels, in the same sense as his earlier term 'interpenetration'., whereas Humberto Maturana's uses structural coupling as a term for the structural correspondence between two or more systems (e.g., cellular organisms).

strong genetic coding for reproduction of the species, but this mechanism cannot readily be translated to the autopoiesis of organisations. We will therefore draw on some of the core ideas of Frankl's logo-theory, building on the existentialist tradition of Kierkegaard and Sartre.

Victor Frankl (1984) claims that the unity of a human being cannot be found in a reduction in the multitude of perspectives, but in the overlaying guidance of meaning. Based on his experience in the concentration camps during World War II, Frankl developed a logo-theory and logo-therapy that emphasizes the role of the "will to meaning" for survival: that we as humans continuously need to find and reproduce a meaning of life to carry on. In the KZ-camp it was a well-known phenomena that a man who no longer was able to believe in any future of his own, was lost. It often occurred very suddenly, and then he stayed in his barrack, laying in his own urine and faeces. Nothing could bring him out of this situation, threats, prayers or blows; every attempt was in vain. The meaning(fulness) must always refer to something in the encompassing world. Self-realisation as a goal in itself cannot substitute this reference to the encompassing world. As Frankl claims, the more a man strives for self-realisation as the end goal, the further away from self-realisation he moves. Only by referring to meaning in the encompassing world, is self-realisation possible as a by-product or spin-off.

Just as meaning is essential to the unity and survival of a human being, we claim that meaning is essential to understand the unity and internal coherence of self-organising heterogeneous social systems/networks like enterprises. As Maruyama expressed it: "For an institution or organisation to be authentic it must be able to transcend itself, just as an authentic individual transcends himself/herself. A paradox is that an institution may consist of authentic individuals and yet the institution or organisation may be inauthentic" (Maruyama 2002, p. 76). Without meaning in this existentialistic sense, the selections of objects and meaning in Luhmann's sense will be arbitrary and the systems will fall apart. Based on this insight, enterprises cannot be understood as homeostatic systems of causality seeking equilibrium. It is meaning or authenticity that makes the increase of nonredundant complexity and self-organizing of heterogeneous systems/networks possible at all.

VIII. The case of multifunctionality

There is a widely shared understanding that future sustainable development of agriculture is a matter of development of multi-functional solutions offered by the different perspectives involved in sustainable development, and that this involves multidisciplinary knowledge (Huylenbroeck and Durand 2003). This understanding is also expressed in the many national and European calls for cross- and multidisciplinary projects (e.g. MEA-Scope, Multagri).

On the face of it, both the notions of multifunctionality and multidisciplinarity seem obvious and easy to apply. However, as indicated above, our experiences from involvement in multidisciplinary teams and from working with the subject of multifunctionality suggest that, first of all, it is very difficult to obtain a common understanding of the research object in multidisciplinary research, and, on top of that, it is very difficult to obtain a common understanding of the notion of multifunctionality.

Three fundamental insights are:
1) Multifunctionality inherently involves a plurality of perspectives. No single discipline can fully incorporate all these different perspectives, and therefore research on multifunctional agriculture has to be multidisciplinary.

2) Multidisciplinarity, in itself, is not trivial. The challenges and problems of multidisciplinarity are deeply rooted in the differentiation into disciplines that operate in different codes, delimitations, times and scales. The differentiation destroys the options for bringing the observations together on the same formula, and multidisciplinary research therefore needs a framework for handling different disciplinary perspectives.
3) The problems with operationalizing the notion of multifunctionality are rooted in the same substantial and fundamental philosophical problematic of communication and cooperation in multidisciplinary teams, but with the added complexity that the perspectives of disciplines here meet the perspectives that are already inherent in the research object, multifunctional farming. The result is that different disciplines operate with different definitions and delimitations of multifunctionality, and this makes it even more difficult to communicate on multifunctional farming.

The paradox of multifunctionality is that, on the one hand, the specialized functionalities of agriculture only arise because of the functional differentiation of social systems and scientific disciplines and, on the other hand, multifunctionality can only enter as a way to mediate between conflicts, interests and fragmented knowledge when different functions and observations of functions combine.

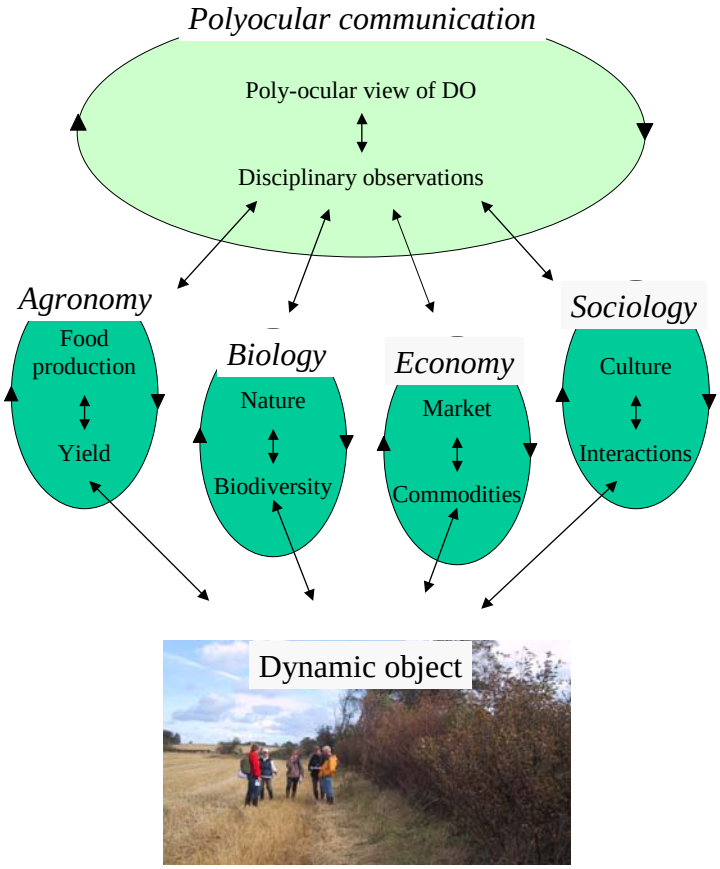

Figure 3: The relationship between discipliniary observatgions and polyocular observations and communication.

IX. A polyocular platform for crossdisciplinary research

Returning again to our initial matter of concern – how to do truly crossdisciplinary research on heterogeneous systems – we can now describe a general platform for observing heterogeneous systems. The paradox of multidisciplinary research is that, on the one hand, the use of a range differentiated and specialized scientific perspectives is the key to deeper and more precise knowledge of a subject field and, on the other hand, differentiation and specialization of science hinders cross-disciplinary communication and thus the application of multidisciplinary research to real world problems. The way forward lies in second order perspectives (Noe et al. 2008, Alrøe and Noe 2008).

The basic thesis for this crossdisciplinary platform is that all disciplinary perspectives are mono-ocular and closed around observation, whereas crossdisciplinary research must be polyocular and closed around observations of a second order, observations of disciplinary perspectives and observations (Figure 3).

References

Alrøe, H.F. (2000) Science as systems learning: Some reflections on the cognitive and communicational aspects of science. *Cybernetics and Human Knowing* 7(4): 57–78. Online at http://hugo.alroe.dk/files/Work/2000-Alroe-Science_as_systems_learning-offprint.pdf

Alrøe, Hugo F. and Egon Noe (2008) What makes organic agriculture move - protest, meaning or market? A polyocular approach to the dynamics and governance of organic agriculture, *Int. J. Agricultural Resources, Governance and Ecology* 7(1/2): 5–22. Online at http://hugo.alroe.dk/files/Work/2008-Alroe_Noe-What_makes_organic_agriculture_move-OFFPRINT.pdf.

Brier, S. 2002. Luhmann semioticized. Paper presented at the *XVth ISA World Congress of sociology,* Brisbane 2002, Research Committee on Sociocybernetics RC51.

Frankl, V.E. (1984) *Man's search for Meaning – an introduction to logotherapy*, Third edition, London, Simon & Schuster.

Huylenbroeck, G.v. and G. Durand (2003) *Multifunctional Agriculture – A New Paradim for European Agriculture and Rural Development.* ASHGATE, Hampshire.

Law, J. 1999. After ANT: complexity, naming and topology. In: Law, J. & Hassard, J. (eds) *Actor-Network Theory and after.* England. Oxford: Blackwell Publisher.

Luhmann, N. 1990. *Essays on Self-reference.* USA. Colombia University Press, New York.

Luhmann, N. 1995. *Social systems.* England. Stanford University Press.

Maruyama, M. (2002) Metamorphosis: authenticity in institutions and organizations, *Methamorphosis* 1 (1): 71-86.

Mol, A. 1999. Ontological politics. A word on some questions. In: Law, J. & Hassard, J. (eds) *Actor-Network Theory and after.* England. Oxford: Blackwell Publisher.

Noe, Egon, Hugo F. Alrøe and Anne Mette S. Langvad (2008) A polyocular framework for research on multifunctional farming and rural development, *Sociologia Ruralis* 48(1): 1–15. Accepted version available online at http://hugo.alroe.dk/Work/Publications.

Noe, E. & Alrøe, H.F. (accepted). Quality, coherence and cooperation: An analytical tool for studying mediation of qualities in food networks and collective marketing strategies. Forthcoming in *Sociologica Ruralis*. Online at http://hugo.alroe.dk/files/Work/2009-Noe_Alroe-Quality_Coherence_and_Cooperation-PREPRINT_05aug2009.pdf.

Noe, Egon and Hugo F. Alrøe (2006) Combining Luhmann and Actor-Network Theory to see farm enterprises as self-organizing systems, *Cybernetics and Human Knowing* 13(1): 34–48. Online at http://hugo.alroe.dk/files/Work/2006-Noe_Alroe-Combining_Luhmann_and_Actor_Network_Theory-offprint.pdf.

Noe, Egon and Alrøe, H.F. (2005) *The challenge of management of multidimensional enterprises analysed from a logo-poietic perspective*. Working paper. Online at http://hugo.alroe.dk/files/Work/2005-Noe_Alroe-Management_from_a_logopoietic_perspective-WORKING_PAPER.pdf.

Noe, Egon and Hugo F. Alrøe (2003) Farm enterprises as self-organizing systems: A new transdisciplinary framework for studying farm enterprises? *International Journal of Sociology of Agriculture and Food* 11(1): 3–14. Online at http://hugo.alroe.dk/files/Work/2003-Noe_Alroe-Farm_enterprises_as_selforganizing_systems-offprint.pdf.

Noe, E. 1999. *Værdier, Rationalitet og Landbrugsproduktion. Belyst ved en microsociologisk undersøgelse blandt danske økologiske og konventionelle kvægbrugere. [Values, Rationality and Farming – Examined in a micro sociological study of organic and conventional dairy farmers*] Ph.D. thesis. Department of Economic and Natural Resources at the Royal Veterinary and Agricultural University

Peirce C.S. (1897, 1908) *Charles Sanders Peirce, Collected papers*. Edited by Charles Hartshorne and Paul Weiss. (Cambridge: Belknap Press of Harvard University Press, 1958-1966)

Ploeg, J.D.v.d. 1994. Styles of Farming: An Introductory Note on the Concepts and Methodology. In: J.D.v.d. Ploeg & A. Long (eds), *Born from Within - Practice and Perspectives of Endogenous Rural Development*. Pp 7-30. Holland. Assen: Van Gorcum.