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**Complex Adaptive Systems Ecology –
A Structuralist Analysis**

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Complex Adaptive Systems Ecology - A Structuralist Analysis

In the following, I will analyze two articles called *Complex Adaptive Systems Ecology I & II* (Molin & Molin, 1997 & 2000). The CASE-articles are some of the more quirky articles that have come out of the Molecular Microbial Ecology Group – a group where I am currently making observational studies. They are the result of a cooperation between Søren Molin, professor in the group, and his brother, Jan Molin, professor at Department of Organization and Industrial Sociology at Copenhagen Business School. The cooperation arises from the recognition that both microbial ecology and sociology/organization theory works with *communities* of sorts. The articles explore if insights from the one field – organization theory – can be used fruitfully in the other field – microbiology.

The two articles are written as prolongations of each other and I will consider CASE I & II to be two parts of the same textual body. It is my main goal with this analysis to localize actants and developmental dynamics, which I can use as guidelines in my later empirical analyses.

1. Methods

As a framework for this analysis, I have chosen to use structuralist literary theory. My primary source is Julienne Algirdas Greimas' "Structural Semantics", from 1966. But I also draw on concepts from Roland Barthes' "Mythologies", from 1969.

I have chosen to use structuralist literary theory for three primary reasons: First, because there is a direct relation between ANT which is an important part of my theoretical background, and important analytic tool in analyzing the data generated using observational studies and Greimas' literary theory. The relations between

literary theory and ANT derive from ANT being inspired by semiotics. Among the central concepts in ANT is the “actant”; it is by using this concept, instead of the more traditional “actor”, that ANT is trying to distance itself from the subject-object distinction basic to the Modern Settlement. ANT proposes instead to focus on relations and networks including human as well as non-human actors. What is interesting in this respect is that the term “actant” is formulated by Vladimir Propp, and later developed further by Greimas in his actant-model, which is central to this analysis.

Second, a reason for choosing literary theory to open up for other analyses is that aesthetic methods in general have the advantage (compared to e.g. sociological ones), in respect to my aim, that the analyzed texts are considered functional actants – non-human actors with their own goals that can form part of networks independent of their human originator. In continuation of this it should be noted that Greimas’ textual theory also acquires the capabilities of an actant, in that it is defined as a stable entity in my text, an entity with a goal of it’s own. Greimas’ theory should not be regarded as an innocent tool, but as an actant, which I am enrolling in a network summoned to support, facilitate, and legitimize my analysis, and the way it is conducted. Thus, already the text is swarming with actants: *In* the analyzed text, the analyzed text *itself*, and the *analytic tools* employed.

Third, I find Greimas’ textual theory relevant here because it is tailored to meet mythical texts. The CASE-articles start and stop with evolutionary narratives, and evolution can be said to a myth *par excellence*. This is the main reason why I find it relevant and interesting to treat the CASE-articles as mythical texts, even if this way of regarding them might not be the most obvious.

Performing a structuralist analysis is not *comme-ils-faut* in academia of today: Reducing and generalizing is central to structuralism, while many contemporary theoretical schools have stopping such endeavors as explicit aims. Thus, it is programmatic for theoretical stances such as feminist science studies, ANT, and pragmatism that there is a deep wish to respect the non-reducible, situated and local. I fully adhere to this stance. But the slightly disrespectful, reductionist element in structuralism also means that it offers efficient tools of extracting textual

elements that are not immediately accessible in the “surface” of the text. And my motive in this reading is exactly to read for something other than that which the intended reader¹ would read for. I am not a microbiologist, and I do not intend to discuss the microbial points of the text. On the contrary, I will read for actants, and thematic and narrative structures. Making this kind of *against-the-grain* reading demands you to put an armlock on the text and reduce, paraphrase, extract... I hope that this analytical conduct can be excused; I do not pretend to dig out some privileged truth about the articles. The only thing I will find is my personal reading of the text, controlled as it is by my goals and intentions.²

I will analyze the text in accordance to a line of classic literary parameters: genre, thematics, and narrative development. In the traditional manner, I will start from without, and gradually work myself further and further “into” the text. Accordingly, my analysis will start with the genre-analysis.

2. Analysis

Genre

CASE I & II is a scientific text, which has been published in microbiological anthologies – *Advances in Microbial Ecology* (Vol. 15, 1997 & Vol. 16, 2000, Plenum Press, New York). The scientific medium means that both the sender’s and receiver’s immediate goals with writing and reading the text are quite explicit and

¹ The position of the reader offered by the text. In other words: The idealized reader, which is inscribed in the text.

² It will become apparent that I do not have it in me to be quite as reductionist as Greimas prescribes. Thus, I am not quite loyal to Greimas’ theory either, but will use the models that I find relevant, I will take the lines of least resistance, and once in a while I will inflate parts of the analyses, which the theory suggests should be treated quickly. Thus, it is not only the *Case*-articles that are held in armlock, Greimas does not get complete freedom of movement either.

easy to decode: The writers want to inform the readers of their scientific work, and the readers want to be informed.³

Even if the context in which the articles are placed is relatively palpable – or maybe exactly because of this – I do not plan to make an analysis that includes the context in the sense of concrete writers and readers. I will – in consonance with the structuralist (semiotic & deconstructivist⁴) intentions – consider the text to be a structure of meaning in it self, independent of concrete writers and readers, their intentions, interpretations and attitudes. When I do consider the text as embedded in a context, it is an intertextual context⁵. This type of approach is more typical of the analysis of artworks than it is of analyses of scientific texts. Frederik Stjernfelt writes the following about differences between the “pragmatic message” and art:

“The artwork is exactly – in contrast to the pragmatic message – characterized by the fact that you cannot, or only in a very restricted sense, use the artist as an answer book if there is something in the work that you don’t understand. If a newspaper editorial, a message from the spouse or a doctoral thesis is unclear, then letters to the editor, questions or opposition ex auditorio is in place – but with an artwork, not so.” (1998: 8. My translation)

In spite of this, it is my intention to read the “pragmatic messages” of the CASE-articles as artworks, and thus *against* their proper genre – scientific literature (at least for a while). Questions and opposition “ex auditorio” will have to wait.

³ It should be mentioned, though, that *Advances in Microbial Ecology* is not the most straightforward microbiological publication. The articles are read as being slightly askew, as having new and unexpected approaches, or conclusions different from the expected ones.

⁴ See for instance Derrida, 1967 (1976)

⁵ This contextual point – that a text derives its meaning through relations to other texts is parallel to another classic structuralist text; Saussure’s “*Cours de Linguistique Generale*” (1974). Saussure settled with the idea that signs refer to something “real”, and argued instead that signs derive their meaning from their relations to other signs.

Structuralist literary theory has been used in the tradition of literary history and criticism, which works with well-known genre-divisions – epics, lyrics, and drama. Several structuralist textual theorists, amongst them Greimas and Propp, who both worked with myths and fairy-tales, have worked out theories that specifically address a specific genre. In consonance with my considering the CASE-articles to be art works rather than scientific texts, I will try to place the articles in a literary genre.

Among the classic literary genres – epics, lyrics, and drama – I find it most fruitful to consider the CASE-articles to be an epic.⁶ Myths and fairy-tales can be placed as sub-genres to the epic genre, and as the CASE-articles present evolutionary narratives, it is logical to place the articles in the epic genre and use some of the parameters of analysis that is traditionally used to approach works within this genre.

The analysis of epic texts is carried out on both the “vertical” and the “horizontal” level – which entails discussing both thematic and narrative structure. The thematic structure can also be called the paradigmatic structure of the text, which refers to the thematic blocks the text is structured around. The narrative or syntagmatic structure indicates how the blocks are placed in prolongation of each other – that is the dynamic progression of the narration.

Thematic analysis

One of central points of structuralist literary theories is that a text will always be marked by repetition, by *redundancy*. According to Greimas, this means that every text is a relatively closed semantic universe, to which radical news is seldom conveyed. Accordingly: the longer the text, the more redundancy. The words a text consists of enter into *seme-communities*⁷, and these do not change significantly through the course of e.g. a novel. The *seme-communities* can also be regarded as paradigms that organize the text as oppositional structures. These oppositions can

⁶ Epics can be defined as broadly descriptive texts with action, lyrics as literature arranged in verses (original meaning; “accompanied by lyre-music”), and drama can simply be described as plays.

⁷ A “*seme*” is Greimas’ concept referring to the minimal unit within semantics, parallel to the minimal unit within phonetics: the “*phoneme*”.

be contrasted graphically, and ultimately the content of the text can be reduced to one overall thematic opposition.

CASE I & II contains a line of oppositions, which I will sketch in the model below. This model, it should be noted, is of my own invention, and not one of Greimas'. After presenting this model, I will discuss the oppositional elements relations to each other, and their bearing on the statements of CASE I & II.

THEME 1	⇔ THEME 2	QUOTES
Empirical Methods	Theory	“Thus, in essence the eco-system is not empirically accessible...and consequently our discussion of eco-systems will be theoretical [...]” (2000: 6) ⁸
Steady state	Real time	“[...] a methodological shift from steady-state to real-time [...]” (ibid.)
Physiologists	Ecologists	“The microbial ecologists often make a point of distinguishing sharply between microbial physiologists and ecologists; the former group usually works with monocultures in laboratory media, whereas the true ecologists only as an exception deal with single organisms, and certainly would not easily accept the laboratory as an ecologically relevant environment” (1997: 29)

⁸ The quotes from CASE II are taken from a pre-print of the article, and the page-numbers may not adhere to the numbers in *Advances in Microbial Ecology*.

In vitro	In vivo	“The principal distinction between in vitro and in vivo experimental conditions, where the former refers to one controlled by the observer... and the latter to one representing natural, uncontrolled conditions [...]” (2000: 4)
Relata	Relations	“[...] to go from relata to relations, from a focus on entities and characteristics to a preoccupation with relational processes; [...]” (2000: 7)
Positivism	Social constructivism	“[...] a paradigmatic step from positivism to naturalistic inquiry and social constructivism” (2000: 7) “Despite the fact that the positivist perception of a single measurable reality seems to dominate both the natural and the social sciences, theories and models from both mathematics and physics ⁹ have demonstrated a need to formulate a new paradigm based on the ontological stance that reality is constructed (or created)” (1997: 31)

Positivism versus social constructivism

In the above model, I have chosen to present the opposition *positivism versus social-constructivism* as being conclusive. Seen this way, the ultimate statement of the text becomes that positivism is performed by physiologists based on empirically based *hard data*. Social-constructivism, in contrast, is theory-driven, and is performed by

⁹ It is interesting to notice that the need for a social constructivist paradigm is pointed out as coming from mathematics and physics. It would be fair to notice that this need is also strong within the social and human sciences. Through invoking exactly mathematics and physics – hard sciences of hard sciences – the text tries to enroll doubting positivists.

ecologists. The interrelated aspects and oppositions could be continued according to the above model, and beyond that in an infinite chain.

Roland Barthes (1969) calls these kinds of couplings *mythical* or *ideological structures*. A *mythical structure* is an ideological mode of thought, which largely remains unconscious to the writer – or which has to be sought out as an implicit aspect of the text. Barthes argues that within the mythical structures one condition is explained unargued with another. Thus, the mythical structures can be regarded as unconscious paradigms. It is important to notice, though, that the *Case*-articles, contrary to myths and fairy-tales, take pains to point out the mythical and ideological character of the text's oppositions and thematics. From within the internal logic of the text we are not dealing with mythical structures. But it is also one of the text's main points that in the world of science, the oppositions work as mythical structures – and that this is wrong as well as dangerous. It is one of the text's explicit points that demystifying the mythical structures will advance microbial research – as well as research generally. This moralizing and normative goal has not been teased out of the text. Rather it is quite accessible to the reader:

“Almost like in a political or religious debate it becomes less important where you are going than where you stand.” (2000: 1.)

“The interesting point here is not who wins the argument, but the intensity encompassing the debate about holy dogmas in the prevailing paradigm.” (ibid.)

Back to myths and fairy-tales: According to Greimas, the basic opposition will be sought dissolved through the means of *mediation*. An example of a well-known theme from the world of fairy-tales is self-command versus urge; an opposition that is mediated through the marriage that often concludes fairy-tales, and which works to dissolve the opposition. Again, it is possible to put CASE I & II into the Greimas' analytic categories, as *mediation* is also the goal here. But it should be noticed that CASE I & II explicitly announces mediation as the purpose of the texts. A myth or a fairy-tale would not imply such an explicit narrative strategy:

“The scope [...] is an invitation to cross the line:
to go from relata to relations [...]
from steady-state to real-time [...]
from positivism to social constructivism [...]” (2000: 7)

The line, which is mentioned in the quote above, could easily be the line between the two sets of oppositions in my model. In the conclusion of CASE II this ambition is mentioned again, this time in an even franker wording:

“We hope to have offered a discussion in principle of the qualitative distinction between what is empirically accessible and what is beyond empirical documentation. We have tried to argue that this is not a limitation due to lack of empirical evidence or limited technological techniques [...]”

“The understanding of life forms in the biosphere springs from the fruitful dialogue between hard data generated through empirical analyses and the imaginative and intelligent construction of descriptions of ecological conditions and evolutionary direction. We consider these two different scientific endeavors to be of equivalent importance and value; being, as they are, complementary in the quest for understanding a complex adaptive systems ecology.” (2000: 56)

In the above quote, the ambition of mediating between oppositional paradigms and positions is quite obvious and explicit. Furthermore, it is emphasized that the oppositional positions are only *apparent* oppositions. *Hard data* and *empirical analyses* on the one side, and *imaginative and intelligent construction* on the other side, are *not* oppositions, but rather complimentary entities of *equivalent importance and value*. The goal of the text is thus to mediate between the two contending parties, which seem to have lost touch with the core of the fight. Incidentally, it is interesting that the religious aspect of the quarrel – which the text criticizes, is presented as a positive aspect of text itself; comprehending the ecology of complex adaptive systems is described as a *quest* - which is a religious search.

However, the mediation of oppositions - the text's quest - is not as straightforward as it may seem on the face of it:

“... our ambition is to base the discussion on a thorough, lengthy line of arguments, concepts and models about relationships between taxonomy, physiological description, ecology and the evolutionary processes.” (2000: 2)

Taxonomy and *physiological description* are elements that can be said to belong primarily to the positivist side of the opposition, while *ecology* and *evolutionary processes* can be found on the social-constructivist side of the opposition. According to this quote, the oppositional elements can only be combined through “thorough, lengthy lines of arguments”. The meticulousness and sober-mindedness that is implied by the use of words is most frequently connoted to the traditional scientific, empirically based – and thereby in the universe conjured up in these articles - positivist side of the opposition. That the text calls upon a traditional scientific way of presenting arguments as warrant of the attempt to combine traditional positivism with social-constructivism indicates that positivism is perceived as dominant in relation to social-constructivism.

This leads me to add another opposition, one that I cannot read directly in the text, but which I perceive as being situated somewhere on the infinite chain of associated concepts and aspects which the mythical structures consists of. This opposition is to be found between “real” science and mysticism, and I will place “real” science in prolongation of the mythical structure that contains positivism, while mysticism, when seen from a positivist view-point, works as associated to social constructivism. Leaning too heavily towards social constructivism will be interpreted as leaning towards mysticism, and mysticism should be avoided at any cost. This I conclude from the pain-staking character of the text, when it time and again explicate that the purpose is *not* to cast away the traditional, positivist science, or laboratory based techniques. The repetitive character of these statements is tinged with warding off blows, which hints at mysticism having in the texts the implicit function of tempter or menace.

When I write "mysticism", "tempter" and "menace", and choose to use exactly these words to describe the content and power-balance in the basic opposition of the texts, I choose the words consciously to direct thoughts towards fairy-tales and myths. In fairy-tales, our hero always has to undergo tests and temptations to achieve his goal – the elimination of the introductory *lack*. If the CASE-articles is a fairy-tale, and researchers – both the writers and the researchers who might accept their invitation to *cross-the-line* – are heroes, then unargued mysticism is the tempter, which must be resisted and fought – not with swords, but with meticulousness, arguments, empirical techniques and theoretical models.

The goal of the text is thus to be the champion of social constructivism, while always showing respect for positivism, for instance by incorporating traditional positivist techniques and *hard data*. Thus, social-constructivist thinking is consolidated in the laboratory-based empirical work, and a bridge is built between the two fundamental oppositions: positivism and social-constructivism, or *in extremis*: "real" science and mysticism.

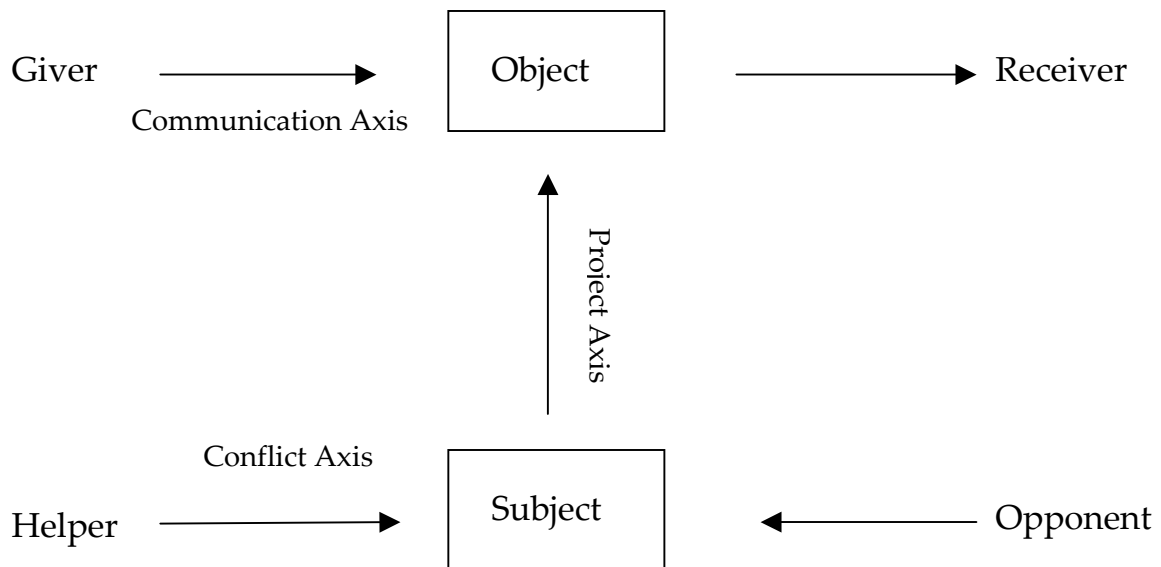
Narrative analysis

Actants

In order to perform a structuralist analysis of the narrative elements of the text it is necessary to reduce or paraphrase the full story to a handful of archetypal situations and transformations. This is done by breaking the text up into *story/suyzhet* and *plot/fabula*.¹⁰ The *story* refers to the text as it is without any kind of reductions. The *plot*, on the other hand, refers to the story in reduced form – it is the skeleton of the story – a completely generalized level of narration, from which the narrative analysis takes off.

In the plot, the characters of the story are deprived of their personality, so to speak, and appear as what is referred to as "actors". Furthermore, Greimas arrange the central actors in 6 classes of interrelations – actants. These six he places in the following model:

¹⁰ For further introduction, see for instance David Bordwell, 1985.



Greimas (1966 (1974): 287)

The most important relation in this model is the relation between Subject and Object. The Subject has a project, which it seeks to realize, and the realization of this project is the Object. The relation between Subject and Object is called the Project-axis. In a folk-tale, the Subject will often be a young man, while the Object is a princess. The acquisition of the object, and the trials the Subject has to go through in this connection, is the material the story is made of. The Object-acquisition can be regarded as a transportation or communication of an Object from a Giver to a Receiver. These relations are called the Communication-axis. The Giver can be a king, who has the power to give the young man permission to marry the princess. The Receiver of the communication-axis is often the young man himself, and in folk-tales, it is not unusual that the Subject and the Receiver is the same actor. The subject meets problems in the fight to acquire the Object. In these trials and confrontations Helpers and Opponents appear. These do not relate directly to the

Object, but are connected to the Subject as support or opposition. These relations are called the Conflict-axis.

In the following analyses of the different transformational levels of the CASE-articles, I will tabulate the actants of each transformation. This is not the traditional way of using the actant-model. Traditionally, an actant model will be tabulated for each subject that can be localized in the text (in folk-tales there is often just one, but in novels there can be several subjects). In this analysis, I have chosen to make actant-models for each transformation, even if the Subject remains the same. Thus, in my different actant-models it is not the Subject that changes but the Giver and the Object. The different actant-models are thus not to be perceived as essentially different, but rather as giving details and specifications of the same overall actant-model. As a matter of form, I will tabulate an overall actant-model below, which will contain the entire story. Subsequently, I will explain this model, and give the analysis more detail.

SUBJECT	CASE I & II
OBJECT	Mediation of Opposition between Social constructivism and Positivism
GIVER:	Empirically Based Hard Data Theoretically based Organization Models and Classification Systems
RECEIVER	Molecular Microbial Ecologists
HELPER	New Social Constructivist Paradigm
OPPONENT	Traditional Positivist Paradigm

Most remarkable about this model is that the Subject of the text is the text itself. The explanation of this peculiarity can be found in the text's status as a scientific text rather than a fictional ditto, which explains why the driving forces of the text are explicated more than in fictional texts. This implies that the text comes to appear as its own subject.

On the axis of conflict (Helper & Opponent), one can see that the text is situated in the field of tension between two paradigms – or mythical structures depending on what level of consciousness one chooses to regard the problem at. It is also

worth noticing that the text is not neutral to this tension, but that the social constructivist paradigm is regarded as a Helper while the positivist paradigm is conceived as an Opponent to the project of the text.

On the axis of communication (Giver & Receiver), we also find that the Receiver of the Object and the Receivers of the text are surprisingly explicitly presented in the text, as was the Subject. The Receivers are, quite simply, the readers of the text – the microbial ecologists who can acquire a new tool, which they can use in their research through reading the text.

Transformations

According to Greimas, the *elementary sequence* of the fabula (The fabula of the fabula, abridged condensation, reduced reduction) is structured around three fundamental situations: Lack, Transformation, and Realization. In the story, the phase of transformation is separated into a number of sub-transformation each one marked by a certain situation.

The starting point of CASE II is a situation of lack, in that the text begins by presenting the scientific community's lack of an up-to-date evolutionary narrative. The situation of lack is indicated in the very first sentence of CASE II: "The discussion of evolutionary issues often tends to polarize the debate." (2000: 1) Questions of evolution are presented as polarizing the debate, a polarization, which serves as starting point for the description of oppositions discussed in the previous section. What is lacking is an evolutionary myth, which can unite the poles and thereby mediate the oppositional mythical structures.

After having established the introductory situation of lack, the text will – according to Greimas – go into the phase of transformations, in which different measures are taken to make good the lack. The transformation-phase takes place by fighting the same fight on five increasingly abstracted levels of microbial research. The first level, which is presented in CASE I is *taxonomy*, while the end level of CASE II is *evolution*. The fights are primarily fought using models, and as promised it is done extremely meticulously.

The thematic analysis showed that the CASE-articles could be read as a clash between two mythical structures. This would go for each of the transformations as

well. Therefore, I will not go into details with every single transformation. In the following, I will mention the most important transformations, explain them crudely, and tabulate an actant-model for each transformation. Concludingly, I will work somewhat more thoroughly on the evolutionary level of the CASE II, as this works as rounding off and finale of the CASE-articles.

Transformation 1: Taxonomy

The fundamental *lack* – of an object connecting the oppositional mythical structures – is transformed for the first time in CASE I, in the presentation of the analytic model *SCIO* (Structure, Coordination, Interaction, Organism). *SCIO* is an analytical model, which is built after an ideal from organization theory (Karl Weick), but which gets coupled to practical microbial laboratory-based research techniques. This is the first connection between the two oppositions – traditional empirical research and social-constructivist theory building.

“The four parameters, *SCIO*, are assumed to be empirically accessible using the methods from microbiology, biochemistry, molecular biology, and microbial ecology.” (1997: 44)

Although the four parameters of *SCIO* are based on something as airy as social-constructivist organization theory, it is still to be conceived as sturdy and robust; the parameters can only be accessed through social-constructivism’s complete opposition; *methods from microbiology, biochemistry, molecular biology, and microbial ecology*. After this quote follows a regular *tour de force* of techniques and technologies that can be used to generate empirical data within the four parameters. Here follows a line of examples:

Organism: Cultivation of pure lines, DNA reassociation kinetics, rRNA identification, rRNA hybridization, fluorescence microscope, molecular tagging,

Interaction: Mass/energy balance, molecular probes, ribosome content, cell size, DNA content, tracers, microelectrodes, molecular tools.

Structure: Scanning electron microscope, light microscope, scanning confocal microscope (SCLM)

Coordination: Coordinated behavior.

For a reader without professional training within the above-mentioned disciplines, this list means very little. Still, one is able to grasp one important point: The theoretical goal of the text may lie within the social-constructivist side of the opposition. This, however, does not equal lack of thoroughness and knowledge of the scientific craftsmanship or empirical meticulousness, which I have placed on the positivist side of the opposition: By presenting the many "hard science" techniques which can be used in achieving a social-constructivist goal, a way in which the two oppositions can be united is presented.

Furthermore, it should be noticed that the above-mentioned empirical techniques will be fewer and fewer as the text moves from the most simple level – Organism – to the most complex – Coordination. Thoroughness and the great professional knowledge slips from the very concrete to the less concrete levels, so that they all appear to be equally empirically accessible. It is possible to make a direct parallel to the coming transformations, which are also gradually removed from the empirically accessible, but still seem as thorough and reasonable craftsmanship because of the threads that are spun from one transformation to the next. The classic approach comes off onto the very abstract levels.

When the first transformation is put into the spaces of Greimas' actant-model, the result looks like this. The actants that differ from the overall model have been emphasized:

SUBJECT	CASE I & II
OBJECT	SCIO-models
GIVER	New Microbial Techniques and Technologies

RECEIVER	Molecular Microbial Ecologists
OPPONENT	Traditional Positivist Paradigm
HELPER	New Social Constructivist Paradigm

At this level of transformation, it is the subject's/the text's project to procure and present the SCIO-models. The object is to be found on the communication-axis and on this axis the new molecular microbiological techniques and technologies are regarded as the Giver. If these techniques and technologies are to be placed within the two oppositional mythical structures, they fit best on the positivist side, which entails that the opposition between social-constructivism and positivism found on the axis of conflict is sought appeased on the axis of communication.

The next transformation consists of combining and perspectivizing the four parameters (Structure, Coordination, Interaction, Organism) in different ways and in different combinations. In these transformations the text draws on knowledge and lingo from organization theory, which hereby replaces microbiology as Giver (and argumentary warrant). By juxtaposing and giving equal rights to microbiology and organization theory the text implicitly mediates the opposition between positivism and social constructivism.

2. Transformation - Physiology

The transformations are continued in CASE II, where the mediation of oppositions is continuously moved to increasingly abstracted levels. The levels to be discussed in CASE II are *Physiology*, *Ecology*, and *Evolution*. The goal of all the transformations is presenting an evolutionary myth, which can work as a final mediation between the two oppositional mythical structures that were presented in the beginning.

The transformation from CASE I's levels (*Taxonomy* and *System-identity*) to CASE II's first level (*Physiology*) is introduced in the following way:

“When the physiological analysis is transferred to communities in natural settings (in vivo) [...] it is considered important to categorize monitorable

parameters and other types of empirical information according to organization relevant types.” (2000: 15)

In the levels and transformational phases that are the content of CASE I, the models are conceived as containers of data generated in laboratories (*in situ* or *in vitro*). With the transformational level of *Physiology*, we are moving from microbial communities that exist *in vivo* – that is in natural settings. Furthermore, the microbial data are again sought categorized using parameters from organization theory. Thus, the two oppositions acquire equal status. The *Community*-model, which graphically represents the level of *Physiology*, still contains the SCIO-model. In this way the *Community*-model also contains the traditionally generated data that the SCIO-models is able to hold, and thus the thread back to the traditional positivist paradigm is unbroken. The mediation of oppositions on this level consists of bringing together models from organization theory (social constructivism) and microbial data (positivism). In an actant-model the transformational level looks like this:

SUBJECT	CASE I & II
OBJECT	<i>Community-model</i>
GIVER	Models and Terms from Organization Theory
RECEIVER	Molecular Microbial Ecologists
HELPER	New Social Constructivist Paradigm
OPPONENT	Traditional Positivist Paradigm

From the above, it can be read that most of the actants in the model are constant in comparison with the preceding one. Thus, it is important to notice that the entire axis of conflict remains constant and that the Receivers are the same. Only the Object and the Giver, which can be found on the axis of communication, has changed since the last transformation. It is no longer microbial techniques and technologies that are the Giver but instead theories and models from organization theory. This logically changes the Object, which is now the *Community*-model – a model that works with communities and collectives.

3. Transformation - Ecology

The next transformation leads to the level of *Ecology*. It is made clear from the very beginning that the level of ecology cannot be discussed without extreme meticulousness on the levels of taxonomy and physiology and I presume that the more warrant the text claims in the one part of the opposition, the more the text leans to the other side, thus maintaining the balance between the two sides:

“In this definition of ecology, the previously described aspects of biological characterizations of microbial systems and communities involving a taxonomic identification framework and physiological investigations are important as platforms for descriptions of ecosystems and ecosystem relations.”

[...]

“Modern molecular microbiology has dramatically changed the tools applicable to microbiology, and it is hardly surprising that the usefulness of these methods and tools has been received with particular enthusiasm by the microbial ecologists, due to the methodological independence of choice of organisms and to the level of resolution and precision of tools... Empirical data may be accumulated from infinitely complex environments, and previous qualified guesses about ecologically relevant parameters may now be verified (or excluded).” (2000: 31)

But after making clear that hard data produced by applying new microbial tools and technologies are crucial also at this level, the text states that it is about to swim against the stream, let data be data and focus on theoretical discussions:

“...there is an important distinction between the analytical processes described so far (all of them being more or less directly empirical) and the following ecological and evolutionary synthetic processes illustrating generalized model construction of relationships in principle between actors and contexts.” (2000: 32)

[...]

“In the ecological synthesis we switch from empirical descriptions to the construction of relational processes, and we do so by introducing ideal-type models and concepts that all evolve around processes. With no platform to take contextual knowledge into further empirically based conceptualization we now take the necessary step toward a non-direct empirical “construction” of the general conditions and relationships characterizing an actor-context in focus (social construction).” (2000: 34)

Here we are told that the text is about to perform a critical transformation, which will lead it away from the data that was positioned as crucial at the outset. We are now moving towards a place that is far more systemic, holistic, or - with positivist eyes – mysterious.

The text relays that whereas the earlier levels were of *analytical* nature we are now approaching a *synthetic* level. The words “analyze” and “synthesize” connotes very different things. “Analyze” can be regarded as belonging to paradigm of positivism and thereby the mythical structure of “real science”, whereas the word “synthesize” connotes social constructivism and the mythical structure of “mysticism”. In the text the difference between analysis and synthesis is explained as follows:

“Through analysis we gain *knowledge* [...] Through synthesis we gain *understanding* [...]” (2000: 33)

The transformation is performed when a new model is introduced – a model that is able to contain the previous models. This time the name is the *Actor – Context*-model. Apart from the terms of *Actor* and *Context* the model contains three key-terms or *Field Forces*, namely *Responsivity*, *Enactment* and *Reflexivity*. The actant-model of this transformational level can be summarized as below. Again, the actants that have changed are emphasized:

SUBJECT	CASE I & II
OBJECT	Actor-Context-model

GIVER	Generalizable Terms from Organization Theory
RECEIVER	Molecular Microbial Ecologists
HELPER	New Social Constructivist Paradigm
OPPONENT	Traditional Positivist Paradigm

Once again, it is the Giver and the Object that has been transformed. The Object of the text is again a model, this time the *Actor-Context*-model, a model that is presented as far more general than the previous ones. This can also be read out of the Giver-actant, which is no longer presented as “merely” organization theory, but as *generalizable* terms of organization theory. Generalizability is a key term within positivism/“real science” and thus a mediation between the two mythical structures is sought performed even on this abstract level.

From this it can be read that the Giver – which could be found on the positivistic side of the opposition in the first transformation – sways further and further towards the social-constructivist side of the opposition as the levels are becoming more and more abstract with the series of transformations.

4. Transformation - Evolution

The last transformation, which should end in a successful dissolvment of the introductory situation of lack, is the transformation to the final and most abstracted level. In the text the previous transformations are summarized accordingly:

“The step from organisms and communities to actors is a conscious, qualitative step from empirical study and analysis to theoretical construction and synthesis.” (2000: 45)

The level of ecology is referred to as *non-directly empirical*, while the evolutionary level is called *a theoretical construction* (ibid). The non-empirical, theoretically founded approach which was presented in the last transformation, is thus radicalized in the current one:

“Instead of building an understanding of evolution on the basis of knowledge about single life forms, we propose to construct a story about life

forms as generalised microbial units that will, at any time, express the holographic characteristics of the evolutionary conditions.” (2000: 46)

The text then goes on to suggest an evolutionary narrative, which is to work as an alternative to the existing ones. In prolongation of this evolutionary narrative or myth a line of goals and requirements are put forth, which in many ways differs from the goals of the dominant neo-Darwinian narrative:

“The evolutionary narrative needs to specify [...] *what* has taken place, *when* it took place and under *which circumstances* it happened. An understanding of evolution will never fulfill the possible wish to explain *why* it has happened [...] The evolutionary narrative is not to be evaluated on its capacity to generate substantial proofs and measures for prediction and forecast. It is evaluated on its quality to spark discussions of complex adaptive systems ecology.” (2000: 47. Original emphasis)

When put into an actant-model, the evolutionary level of transformation looks like this:

SUBJECT	CASE I & II
OBJECT	Diversification-model
GIVER	Narrativity
RECEIVER	Molecular Microbial Ecologists
OPPONENT	Traditional Positivist Paradigm
HELPER	New Social Constructivist Paradigm

Again, it is apparent that it is the Giver and the Object that changes. This time the Object is a model referred to as the *Diversification-model*: a model, which visually represents the evolutionary myth that has been hinted at ever since the introduction to CASE II. The Giver is Narrativity. Thus again it is obvious that the Giver has moved from the positivistic side of the opposition towards the social-constructivist one through the different levels of transformation. The Object of this

actant-model, the *Diversification*-model is the last step in the transformation process and should thus, according to Greimas, be the answer to the introductory situation of lack, the object of the transformations, and the mediation of the oppositional mythical structures. Since so much is invested in this myth, I will use some time on presenting, discussing, and analyzing it.

The evolutionary myth

The presentation of the myth is introduced with emphasizing that this level of transformations belongs only to the social-constructivist side of the basic thematic opposition. Therefore, narrativity is the preferred method when approaching the evolutionary myth. That means that the evolutionary myth is not to be understood as a retrospective explanation of the evolutionary development so far, or as a prescriptive anticipation of what is to come, but rather as a framing of all the levels and transformations of microbial research that the text involves:

“According to our social constructivist point of departure a comprehensive theory about complex adaptive systems will become a narrative signifying the particular modeling of life forms in a biosphere that is constituted by the beholder...” (2000: 47)

The text presents two narrative levels that the evolutionary myth works within: *Evolutionary Direction* and *Evolutionary Forces*. The Title of the *Evolutionary Direction* is *Diversification*, and through this title it is made clear that the narrative about to be presented is broad and non-exclusive. Furthermore, the text describes *Diversification* as “constancy amidst change” (2000: 49), which underlines the broad character of the evolutionary direction.

The text then suggest four sub-directions of *Diversification*: *Complexity*, *Symbiosis*, *Proliferation* and *Diversity*: *Complexity* refers to a process that creates more and more integrated and specialized repertoires of action. This means that the systems which the microbial organisms are parts of are characterized by progressively increasing numbers of feedback loops, connections and relations. The text suggests that increased complexity entails that the system in question has a

stronger defense against pollution. *Symbiosis*, on the other hand, is a process where fundamentally different characteristics of different organisms are fused. Symbiotic relations can exist in many degrees – from loose associations between two different organisms, to a complete fusion, which leads to a completely new organism. *Proliferation* is indicative of quantitative growth in the number of organisms, without this growth adding any new variants. *Diversity*, on the other hand, creates variations and differences.

As indicated above the four directions can be read as pairs and symmetries: Progressively more complex societies with specialized assignments and couplings are created (Complexity), and at the same time organisms fuse and become one (Symbiosis). In the same way *Proliferation* and *Diversity* forms a pair: Evolution creates variations and differences between single species and organisms (Diversity), and it creates unvaried growth of the same type of organism (Proliferation). The mediating balancing act, which was pointed out as central to the text as early as the introduction, can thus be found in the finale of the text as well:

“The evolutionary narrative describes the changing counterbalancing between the four diversificatory processes, that is, the way diversity may be confronted by combinations of symbiosis-proliferation-complexity to generate periods of orderliness and stability.” (2000: 52 - 53)

Likewise, the *Evolutionary Forces* can be seen as pairs: The text surprisingly uses the Darwinist terms of *competition* and *selection* to describe the dynamics that drives the evolutionary processes. But the Darwinian picture is immediately subdivided into two complimentary forces, and balance and symmetry is again extrapolated in the text: There are two principles of selection and competition; an *explorative* principle and an *exploitative* principle. That is: there are *explorative* evolutionary forces that cause *transformation* and there are *exploitative* evolutionary forces that cause *stability*. Again the mediating balancing act is extrapolated: There is one evolutionary force that *stabilizes* and one that *transforms*, and the balancing act can be found in the titles of the evolutionary forces - selection and competition: Before presenting this myth the text placed itself fully in the social-constructivist side of the basic

opposition. Afterwards the text – surprisingly to this reader – uses Darwinian concepts to describe the evolutionary forces. But maybe it is not that surprising, after all. By showing respect to the other - positivist and neo-Darwinian - side of the opposition (and I guess that using central Darwinian concepts in the very finale of the text can be regarded thus) the balance between the two sides of the opposition is maintained. Or even stronger – they are weaved together in the same evolutionary myth and can within this frame no longer be regarded as oppositions. And hereby the text ends by dissolving the introductory situation of lack and by mediating and detraumatizing the thematic opposition.

4. Conclusion: The Danger of Non-Science

An essential part of the driving forces of the CASE-articles are not embraced by the above structuralist analysis, even if this part can logically be placed within the same terms and framings. What I am referring to is *the threat, the danger, or the tempter*; that which threatens the Subject if the project of the Subject is not successfully brought to an end. In this case, the Subject is the text itself and thus my question becomes; what threatens the success of the text? Already in the discussion of the text's oppositions, I mentioned that the mythical structures behind the oppositions could be continued indefinitely. When seen from an intertextual perspective they can be seen as holding "real" science on the positivist side, and mysticism on the social-constructivist side. It is the danger of mysticism that I find crucial to this text. The overwhelming meticulousness and the warrants in "real" science presented for every argument reflects this danger: The danger of becoming holistic and mystic, and basically, non-scientific. It is this balancing act; of importing enough - but not too much - new thinking into the traditional scientific paradigm that I will pursue in the following chapters.

5. Literature

Bordwell, David, 1985, *Narration in the Fiction Film*, The University of Wisconsin Press, Madison.

Derrida, Jacques, 1967 (1976), *Of Grammatology*, Johns Hopkins University Press, Baltimore.

Greimas, Algirdas Julien, 1966 (1974), *Strukturel Semantik*, Borgens Forlag, København.

Molin, J. & Molin, S., 1997 & 2000, *CASE I & II – Complex Adaptive Systems Ecology*, Advances in Microbial Ecology, Vol. 15 & Vol. 16., Plenum Press, New York.

Propp, Vladimir, 1927 (1968), *Morphology of the Folktale*, University of Texas Press, 1968 [1927], Austin.

Saussure, Ferdinand de, 1966, *Cours de Linguistique Générale*, McGraw-Hill, New York, 1966.