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Löfgren, Lars

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LUND UNIVERSITY

PO Box 117  
221 00 Lund  
+46 46-222 00 00

# FRAGMENTABILITY, A FOUNDATIONAL SYSTEMS CONCEPT

LARS LÖFGREN

University of Lund

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*A latest proof of the paper is what follows.*

# Fragmentability, a Foundational Systems Concept

Lars Lofgren (email: Lars.Lofgren@it.lth.se)  
Systems Theory, University of Lund, Box 118, S-221 00 Lund

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## Abstract

Fragmentation is a fundamental process, beneath the level of logics. Fragmentation occurs in our most everyday activities. We analyse (literally, to break into fragments), describe, and interpret by performing fragmentations.

We propose a linguistic concept of fragmentation, namely a complementaristic whole of “syntactic fragmentation” and “semantic fragmentation”, as foundational for Systems and, in particular, General Systems.

## 1 Fragmentation and Unification

Every description, even a whole descriptive theory, is a description of something, not everything. Indeed, we do describe by making fragmentations. Were it not for the remarkable property of nature that it seemingly allows fragmentation, as in our becoming conscious of a particular phenomenon as target for description, or as in the isolation of a particular physical phenomenon in an experimental set-up for measuring an observable, every attempt at describing nature would fail.

Chew explains further:

[Chew G, 1968]. “A key discovery of Western culture has been the discovery that different aspects of nature can be individually ‘understood’ in an approximate sense without everything’s being understood at once. All phenomena ultimately are interconnected, so an attempt to understand only a part necessarily leads to some error, but the error is sufficiently small for the partial approach to be meaningful. Save for this remarkable and far from obvious property of nature, scientific progress would be impossible.”

We may look upon this view as suggestive of a fragmentation problem.

**Fragmentation problem.** Is nature in itself fragmentable, and thereby non-distortively describable, or, is it our linguistic description processes which make nature appear fragmentable.

The involved notion of (*non-*)*distortive* may be clarified with an example from quantum mechanics. Consider an entangled EPR pair of particles. They may have become light years apart, suggesting that the pair is fragmented into two parts, the individual particles. But such a fragmentation turns out distortive on the pair as a quantum mechanical entity (where entanglement indicates an unbreakable quantum correlation between the particles).

Further examples of unbreakable wholes, i.e., wholes that will be distorted when operated upon by a classical fragmentation, will be given subsequently. Language itself will prove a prime example.

The concept of *nature*, occurring in the Fragmentation Problem, is to be understood constructively, as in Linguistic Realism [Löfgren L, 1993]. Accordingly, we are open to a reality including human constructs – as well as languages (complementaristically conceived; see below). What may be distortive on this scale of linguistic realism, requires an evolutionary perspective.

The fragmentary growth of knowledge, particularly into scientific disciplines, creates unification problems, like quests for disciplines with larger, unifying domains.

**Unification Problem.** Is there a unifying understanding of fragmented scientific disciplines?

A first natural proposal would be an *interdisciplinary* understanding. This presupposes however a rather classical part-whole view, as if various disciplines (parts) can be joined together, possibly extended with new rules for previously not covered parts of the larger domain of inquiry. Compare as well earlier, classical formulations of so called *inductive rules of inference*,

where induction is looked at as some sort of generalizing inference from particular observed facts.

However, as we now think of induction, [Löfgren L, 1982], it is not an inference from particulars – but a process bringing forth hidden properties of the language in use. That is, properties beyond analytic deductive accessibility within the language. Such properties are acquired in the evolution of the language, in its adaptation to environments for which it works. They are accounted for in the complementaristic conception of language (section 3). Complementaristic conceivability will provide an answer to the unification problem as well as to a quest for noncumulative growth of knowledge.

## 2 Fragmentability of Wholes; earlier insights

By way of introduction to our *complementaristic concept of fragmentation* (section 4) let us collect some earlier formulations of basic fragmentation hypotheses and doctrines.

In Russell's chapter on Analysis in [Russell B, 1961], he writes:

“The operation by which, from examination of a whole W, we arrive at 'P is part of W', is called 'analysis'. It has two forms: logical analysis, and analysis into spatio-temporal parts.”

Russell's categorical fragmentation here, the separation of the two forms of analysis, indicates that he is on a classical (noncomplementaristic) ground allowing classical analysis of fragmentation. No complementaristic relations between the two forms of analysis are hinted at.

**Part-hole doctrine, I.** [Russell B, 1961, page 157]: “the parts of a complex whole are different, as combined in that whole, from what they would otherwise be.”

**Part-Whole Doctrine II.** [Russell B, 1966, page 327] “From the earliest times, many philosophers have objected to analysis: they have maintained that analysis is falsification, that a whole does not really consist of parts suitably arranged, and that, if we mention any part singly, the act of isolation so alters it that what we have mentioned is not an organic part of the whole.”

[Russell B, 1966, page 327] also recalls a principle of atomicity “which may be said to forbid synthesis. Linguistically, it forbids the giving of proper names to complex wholes, at any rate when they are recognized to be complex.” For my part, says Russell, I reject

both these extremes [the first referring to doctrine II, which is similar to I].

**Part-hole doctrine III.** [Russell B, 1966, pages 333-334]: “Can we state all that we know without the use of any basic propositions of the form ‘P is part of W’? In asking this question it is supposed that ‘P’ and ‘W’ are proper names. It is assumed that we can experience a whole W without knowing what its parts are, but that, by attention and noticing, we can gradually discover more and more of its parts. It is not assumed that this process must stop short of complete analysis, nor is it assumed that it can be carried to the point at which the parts that have been arrived at are incapable of further analysis. But it is assumed that the whole W can preserve its identity throughout the process of analysis: that, e.g., in perception we can begin with ‘W!’, as an exclamatory use of an object-word, and arrive, by attention, at ‘P is part of W’, without any change in the denotation of the name ‘W’.”

The following part-whole characterization is developed in a wide evolutionary context, relevant for the so called systems movement (see [Klir G, 1991, chapter 3]).

**Part-hole doctrine IV.** Smuts 1926 *Holism and Evolution*, quoted in [Klir G, 1991, page 29]: “A whole is a synthesis or unity of parts, so close that it affects the activities and interactions of those parts, impresses on them a special character, and makes them different from what they would have been in a combination devoid of such unity or synthesis. That is the fundamental element in the concept of the whole. It is a complex of parts, but so close and intimate, so unified that the characters and relations and activities of the parts are affected and changed.”

A fragmentation principle, which is often hidden deep in foundational logical issues, is the principle of compositionality.

**The principle of compositionality** says that the semantic attributes of a complex expression are functions of the semantic attributes of its constituent expressions.

The principle presupposes fragmentabilities on both syntactic and semantic levels and states a recursive-like correlation.

[Hintikka J, 1996, page 106]: “Tarski had an early form of a categorical grammar. Any approach like

categorical grammar presupposes certain things of the semantics of the language whose grammar it is supposed to be. It presupposes that the language in question satisfies the requirement which linguists usually call *compositionality*. Philosophers sometimes refer to it as the Frege principle, and Frege did indeed pay lip service to it. As usually formulated it says that the meaning of a complex expression is a function of the meanings of its constituent expressions. It is nevertheless appropriate to extend the idea of compositionality to say that all the relevant semantical attributes of an expression (and not only just its meaning or truth) are functions of the semantical attributes of its constituent expressions (not just of its meaning). The major impact of the principle of compositionality on logical and linguistic theorizing is to allow what is usually referred to as recursive definitions (or other kinds of recursive characterization) of the relevant semantical properties. That is to say, we can specify the conditions for the applicability of the semantical attribute in question to the simplest possible expressions, and then specify, step by step, for each operation of forming complex expressions out of the simpler ones, how applicability of that semantical attribute to the complex expression is derived on the semantical attributes of its constituent expressions. ...

The real impact nevertheless has not been emphasized in recent discussion. It is illustrated by the role of the principle in facilitating recursive definitions of semantical attributes. Such recursive definitions proceed from simpler expressions to more complicated ones. They are not possible unless the attribute to be defined is semantically speaking *context independent*. The main function of the principle of compositionality is to secure such semantical context-independence.”

[Hintikka J and Sandu G, 1996] exhibit an “independence friendly” first order logic which violates the principle of compositionality. The authors look at the semantical incompleteness of this logic as its most profoundly revolutionary feature.

Let us next, as a preliminary to the language-based fragmentation concept, recall the complementaristic concept of language [Löfgren L, 1992].

### 3 General Language – a Complementaristic Whole

Phenomena of language are at the bottom of all human activity and are, indeed, at the roots of all forms of life as genetic processes. The phenomena are extremely rich, and exceedingly difficult to conceptualize without distorting them in the act. Yet, at the same time, our communication languages are so natural and easy for us to use that we hardly notice them. It is as if they were universal, as if what we are saying had an absolute meaning which were independent of the

language in use. As if the language could be detached from the ideas we are talking about. Such impressions fade away, however, when we try to objectify, or conceptualize, language. We then realize our *linguistic predicament*: to objectify language in language.

On the basis of several earlier investigations of language phenomena, from genetic language, through programming language, formal language, observation language, inner cerebral language, to external communication language, we have come to the conclusion that there is a common concept of language, of which all these phenomena are species.

**Language**, in its general conception, is a whole of complementary description and interpretation processes.

The involved concept of complementarity, the *linguistic complementarity*, is to be understood as follows.

**The linguistic complementarity.** In general, complementarity refers to holistic situations where (a classical) fragmentation into parts does not succeed. In its complementaristic understanding, the phenomenon of language is such a whole of description and interpretation processes, yet a whole which has no such parts fully expressible within the language itself. Instead, within the language, the parts are complementary or tensioned (rather than classically contradictory). There are various related ways of looking at the complementarity:

- (i) as descriptiveness incompleteness: in no language can its interpretation process be completely described in the language itself;
- (ii) as a tension between descriptiveness and interpretability within a language: increased descriptiveness implies decreased interpretability, and conversely;
- (iii) as degrees of partiality of self-reference (introspection) within a language: complete self-reference within a language is impossible;
- (iv) as a principle of “nondetachability of language”.

**The linguistic closure.** Our thinking abilities are usually looked upon as free and unbounded. But when it comes to *communicable thought*, we are confined to some shared communication language. The systemic wholeness, or the complementaristic nature, of this language implies a closure, or circumscription, of our linguistic abilities – be they “pure thoughts” communicable in a formal mathematical language, or constructive directions for an experimental interpretation-domain of a physics language. The

nature of this closure is not that of a classical boundary of a capacity, like describability, or interpretability. It is a *tensioned and hereditary* boundary of the systemic capacity of *describability-and-interpretability* admitting *potentialities* in two directions:

(a) The closure is **tensioned**. Within the language there is a tension between describability and interpretability (view (ii) of the linguistic complementarity), whereby it may be possible to increase the describability at the cost of a lowered interpretability, and conversely. In other words, what the closure bounds off is neither describability, nor interpretability, but their interactive whole as a linguistic unit of *describability-and-interpretability*.

(b) The closure is **hereditary**. Languages evolve, and at a later time we can have access to another shared communication language of greater communication capacity. However, we are then back to the *linguistic predicament*: at each time we try to communicate thoughts – even introspective thoughts about language and their evolution – we are confined to a shared language, however evolved, and the linguistic complementarity of that language restricts our communicability in the tensioned way according to (a).

#### 4 Language-Based Fragmentation

A fragmentation of a whole produces parts (fragments) of the whole. The parts must be *distinguishable*. Otherwise, by Leibniz's principle, indistinguishable parts coalesce and the fragmentation of the whole is nullified.

Fragmentability is thus intimately connected with distinguishability, and distinguishability with describability. See [Löfgren L, 1966] for distinguishability (of elements in a domain) as describability (of the domain).

Again, describability is complementaristically related with interpretability. This means that fragmentation, visualized as occurring in the interpretation domain of a language, is nonseparable from a fragmentation view in the description domain.

**Fragmentation** is objectifiable as a linguistic phenomenon, a whole of “syntactic fragmentation” complementaristically inter-related with “semantic fragmentation”.

To help clarify the complementaristic nature of fragmentation, and of language, we want to mention a contrasting earlier understanding of language in terms of *semiotics*, proposed by Carnap in the early 40's (with beliefs in classical unification principles). He suggests a classical fragmentability of the whole science of language (not reflecting any complementaristic quality of language).

**Carnap's fragmentation thesis for Semiotics** [Carnap R, 1942, page 9]. If we are analyzing a language, then we are concerned, of course, with expressions. But we need not necessarily also deal with speakers and designata. Although these factors are present whenever language is used, we may abstract from one or both of them in what we intend to say about the language in question. Accordingly, we distinguish three fields of investigation of languages [pragmatics, semantics, syntax]. The whole science of language, consisting of the three parts mentioned, is called *semiotic*.

True that the assumed fragmentability may be described in a metalanguage, provided one such exists. But “the whole science of language” is not a science unless connected with a language (in which it is described). That is, the actual language (with no appeal to some metalanguage; of the linguistic predicament) for which the fragmentation is supposed to hold. But, by our analysis of language, this fragmentation cannot be made within this language itself. What is missing in Carnap's account of semiotics, as “the whole science of language”, is a complementaristic relation between the suggested parts. In other words, if Carnapian semiotics is considered the whole science of language, it is distortive of language as in linguistic realism.

We suggest that *semiotics* be developed accordingly. Also, that pragmatics be understood in terms of the processual nature of the description and interpretation processes.

The complementaristic concept of language is a whole which satisfies the part-whole doctrines I, II, and IV (section 2). For example, the stipulation that “the parts of a complex whole are different, as combined in that whole, from what they would otherwise be”, holds for language. Its constituent interacting description and interpretation processes, producing descriptions and interpretations, are intuitively clear in a classical global perspective (with descriptions as finitely representable, static, objects – with meanings, or interpretations, beyond any such restrictions). However, when these parts are made objects for investigation in the language itself, they become non-classical tensioned objects.

The assumption in doctrine III, “that we can experience a whole W without knowing what its parts are”, is satisfied by *complementaristic conceivability*, recognizing human conception of description-interpretation wholes.

The principle of compositionality is not assumed for complementaristic language. Rather, the role of the principle to secure semantical context-independence, seems more in line with a Carnapian fragmentability

of semiotics, than with, say, the principle of non-detachability of language.

## 5 Systems Movements Towards Unifying Foundations

[Klir G, 1991, chapter 3] provides an interesting account of movements towards *unification* as characteristic for the emergence of systems concepts and systems thinking. Klir notices that current systems thinking, in studying the relationship between wholes and parts, goes far beyond thinking molded from either reductionism or holism. He points at the recognition of interdisciplinary domains as a step towards recognizing *systemhood*, elaborated in [Rosen R, 1986] in a foundational setting.

In our view, there is an undisputable unifying effect in foundational studies. Various disciplines recognize different domains of inquiry, and work with different presuppositions create unification problems. The more the presuppositions can be explicitly revealed, the better can an interdisciplinary communication be developed. Revelation of presuppositions is an act of introspection in the language in which a discipline is – inductively and deductively – developed. Such introspective acts are what we usually call *foundational*. Deep foundational studies do not merely refer to disciplines as context dependent. They take the context all the way to language as the ultimate frame of reference for communicable knowledge (cf the linguistic closure for the general complementaristic concept of language).

Let us very briefly comment on some steps in the movements towards system out from fragmentability as a foundational systems concept.

### 5.1 On Rosen's Critical Comparison of Systemhood with Sethood

Attempting to answer the question what a system is, [Rosen R, 1986] compares the concept of system with that of set. In spite of many parallels, Rosen critically distinguishes between “systemhood” and “set-ness” and suggests that:

“since the axiom systems in terms of which set-ness is characterized are themselves *systems*, it may well be that attempts to define systemhood in terms of set-ness is cart before horse. ...

The task of General Systems Theory is a large one. It is not only to characterize and study the notion of systemhood, and the properties which depend only upon it. More than this, it is up to General Systems Theory to divide the pie between what we have called thinghood, set-ness and systemhood, and study the hybrid properties which depend on more than one of these primitives.”

This is indeed a genuine fragmentation problem. With the “pie” conceived as in linguistic realism, General Systems Theory ought to study presuppositions for sets and for systems, and to understand fragmentability accordingly. That may seem to require a General Systems Language with a complementaristic account of such presuppositions and their fragmentability.

Traces of such a shift from theory to language may be seen in Rosens first remark on “axiom systems”. Recall how Gödel, in his revised conception of a “formal system” includes with the “pure” syntax also a complementary semantic appeal to Turing machines (whereby a proof-regress is avoided; cf [Löfgren L, 1998]).

### 5.2 On Spencer-Brown's Laws of Form

[Spencer Brown G, 1969, page v]: “The theme of this book is that a universe comes into being when a space is severed or taken apart.

...

By tracing the way we represent such a severance, we can begin to reconstruct, with an accuracy and coverage that appear almost uncanny, the basic forms underlying linguistic, mathematical, physical, and biological science, and can begin to see how the familiar laws of our own experience follow inexorably from the original act of severance.”

Here we have an attempt at fragmentation (severance, taking apart) as a foundational concept, inviting comparison with linguistic fragmentation as a complementaristic whole of “syntactic fragmentation” and “semantic fragmentation”, By contrast, Spencer Brown works with a compositionality that reduces to syntactic forms.

To say “that a universe comes into being when a space is severed or taken apart” obviously presupposes an already existing linguistic fragmentability. Spencer Brown works with fragmentability as unproblematic, as if perfect fragmentations can always be made (“distinction is perfect continence”). Such presuppositions may be defended in strictly discrete universes.

But consider a language, say a mathematical language, where for example choice processes occur. Even though these can be *partially* axiomatized, as choice functions beyond rules, they show up as independent axioms. Mathematical reasoning in a mathematical language may well use processes which are beyond full syntactical description in the language.

To understand language, as the complementaristic phenomenon it is, in terms of fragmentation it is necessary to recognize also fragmentation as a complementaristic phenomenon. A pure syntactic fragmentation will not suffice, not even for pure mathematics.

### 5.3 On Self-Reference

[Varela F, 1975] attempts an extension of the calculus of indications of Spencer Brown “to encompass all occurrences of self-referential situations”.

However, reference is centrally linguistic, and self-reference refers to (features of) the language in which it occurs. Complete self-reference is impossible (view iii of the linguistic complementarity). Self-reference is always *partial*. For a study of this partiality we refer to [Löfgren L, 1990].

Varela does not refer to language, and not to the necessary partiality of self-reference. However, in his conclusions, he refers to a separation between observer and observed. He suggests that:

[Varela F, 1975, page 22] “In contrast with what is commonly assumed, a description, when carefully inspected, reveals the properties of the observer. We observers, distinguish ourselves precisely by distinguishing what we apparently are not, the world.”

In [Löfgren L, 1996, page 335] we have explained various presuppositions needed to make this formulation (of “post-objectivity” in second-order cybernetics) appreciable.

### 5.4 Time

For a recent study of the fragmentation problem for time we refer to [Löfgren L, 2000].

## 6 Conclusion

General System, in contrast to more disciplinary domains, is supposed not to overlook problems of synthesis – which usually are abstracted away in reductionistic studies towards “disciplinary foundations”.

Yet, to understand General Systems, we are forced to perform fragmentations that are tied with descriptions and interpretations of the subject. The complementaristic concept of fragmentation is proposed as foundational for Systems, in particular for General Systems.

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