

Thermodynamic metaphors

A discussion of basic ideas in cognitive semantics exemplified in a hot topic

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In this paper, I shall presuppose as well-known the basic features of the theory of metaphor in the Cognitive Semantics tradition (as presented by Lakoff and Johnson 1980, developed in Lakoff 1987, expanded in Lakoff and Turner 1987 and taken further in Lakoff and Johnson 2000 and in a different version in Fauconnier and Turner 2002. Here, I shall take Lakoff's version to be prototypical for the cognitive semantics tradition, but my points will be relevant for the other variants of the theory as well.) The idea is that metaphors not only prevail in poetry but also in all sorts of everyday reasoning and language. This omnipresence of metaphor in language now points to its central role in thought on a structural level so that one and the same conceptual metaphor may give rise to a variety of linguistic expressions. Thus, in many languages it is possible to make a series of specific metaphors based on the more general, conceptual metaphor UNDERSTANDING IS SEEING which then must be posed as a sort of deep structure lying behind different idioms: "It is clear that ...", "Don't you see that ...", "His point of view is somewhat foggy ...", "The Enlightenment", "insight" etc. etc. To Lakoff, this metaphor will be based on the idea of the mind as a kind of container, from which understanding emanates as a kind of gaze aiming at the objects understood. As such, it is composed of two basic, so-called "image schemas" - the container and the source-path-goal schema - mapped from the domain of vision onto the domain of understanding. All in all around 10-15 of these image schemas constitute, according to this theory, a series of formal semantic "atoms" having a Gestalt character making them able to conceptualize widely varying semantic domains. These schemas are supposed to be immediately understandable because of our being bodies - because we are bodies we know what containers and teleological movements are - and hence we just expand our bodily knowledge from this basis to structure more abstract or difficult domains so that poetry as well as science are metaphor-supported activities. These less simple domains of course may be conceived of by means of several different metaphors each of which emphasizes just one single aspect of the subject (love as a journey, but also as an illness, as madness, as a physical power etc.). Lakoff names these schemas "image schemas"; in this lies not only their connection to intuition but also a specific epistemological claim: the schemas are formal in so far as they may subsume widely varying content, but they are not formal in so far as they may be given a purely logical

description - quite on the contrary Lakoff imagines that formal logic as we know it is a derivative from the image schemas which eo ipso are not describable by its means. On the other hand, Lakoff is cautious in not ascribing the schemas any kind of a priori status; his epistemological position he names “experientialism”, assuming the schemas to be aposterioric and connected to the specific organization of the human body. As Peer Bundgaard has emphasized, Lakoff’s theory does not explain how these schemas emerge from the interaction of the body with the world; this emergence is merely presupposed, and I have myself argued that all the talk about “embodiment” in the theory, however sympathetic in its striving for a phenomenological foundation, is for this reason rather loose. Another problem in this connection is the definition of the “domains” or “fields” which the metaphorical mapping is supposed to take place between; any precise definition of the status of these domains does not seem to be accomplished.

Here, I shall investigate a candidate to a schema in this Lakoffian tradition, which is not yet mapped in its topography - one, or maybe several interrelated, thermodynamical schemas. To present it, I shall begin by considering a series of Danish metaphors for abnormal states and conditions of mind. First an easily Lakoffable example:

“Han er formørket” (“He is darkened”; the Danish saying often used about f.inst. the later Nietzsche)

vs.

“Han er et lyst hoved” (“He is a bright head”)

UNDERSTANDING IS LIGHT is of course the Lakoffian metaphor lying behind these expressions which are connected to several other related ideas (the mind as a searching gaze, etc.), a metaphor at work in a very large amount of specific metaphors in many languages. The version mentioned here involves at first glance simply two poles, mental ability versus lack of it, which is then correlated to light and darkness respectively (and with a tendency also to map onto the couple normal vs. abnormal). To be “darkened” thus refers to conditions which we clinically would characterize as due to low intelligence (mentally disabled, or the like) as well as to conditions clinically to be described as psychotic (schizophrenic, manio-depressive, etc.), as well as conditions clinically described as normal, albeit on the margin of the spectrum of normality. This metaphor, then, simplifies a complicated cognitive field, even if it has a variant which yields a further differentiation of the domain:

“Han har set lyset” (“He has seen the light”)

“Hun er forblændet” (“She is blinded”)

corresponding to the idea that an overdose of light may damage or lead astray an eye - respectively, a mind - whose capacity is not sufficient. When having ‘seen the light’ or being ‘blinded’, one is monomaniacally caught up in one single, often sect-like belief. Still, this metaphor seems to be dual and to be based on a continuum from darkness to light, mapped by a scalar image schema; this further elaboration of it just cutting the continuum up into three distinct parts with the normal condition in the middle. This tripartition of the amount of light does not seem to contain any further internal structure, but seems to rest on a simple “golden middle way” schema localizing a normal area between two opposed types of deviation.

But what is interesting here is that other metaphors for the same domain seem to have a three-part structure which does possess an internal articulation, for instance this complex of metaphors built on thermodynamical phases:

“Han har jord i hovedet” (“He’s got soil in his head”)

[Eng. variant “He’s a blockhead”]

“Hun hælder vand ud ad ørerne” (“She pours water out her ears”)

“Han har flyvske tanker” (“He’s got flying thoughts”)

“Luftige ideer” (“Gaseous ideas”)

“Han er fuldstændig blæst” (“He’s completely blown”)

“Hun har gennemtræk på øverste etage”

(“She’s got a draw in the upper floor”)

[Eng. variant “Brainstorm”]

This three-part metaphor seems to distinguish a (rarely expressed) normal state of mind in the middle, corresponding to the liquid phase (to ‘pour water out of one’s ears’ means to keep on talking about insignificant subjects and is a trivial but still normal process) - opposed to two specific forms of deviation corresponding to the solid and gaseous phases, respectively. The solid phase corresponds to stupidity and clinical imbecility while the gaseous phase corresponds to madness and clinically psychotic states. Of course, in the everyday use of the metaphors they are most often used about small deviations within normality rather than about proper clinical cases about which a widespread delicacy is the norm. The air phase, however, has also affinity to intensive thought (“brainstorm”); this metaphor thus implies a continuum between more or less clinical “madness” and intensive thought. (Yet, English “storm” involves rain or snow; there are then still drops of liquid in the air present ...). One could propose that this phase theory of the mind also is the conceptual metaphor behind the spontaneous distinction of

various specific types of nonsense in Danish: “lort” vs. “gylle”/”pis” vs. “fis” (Eng. “shit” vs. ”piss” vs. ”fart”) which consequently is used about behaviour or expressions being stupid, fallacious (but otherwise normal), and crazy (or funny), respectively. The domain which in these metaphors are superposed onto thermodynamic phases and states of mind with a more complicated metaphor as the result, is the idea of deplaced bodily substances. The three abovementioned products of the intestines are supposed to make their way to the upper region of the body where they do not belong. This construction, hence, presupposes a futher idea (“the head is mental” vs. “the body is material”, itself being metaphorical). In a semi-comical Lakoffianism, this metaphor might be summarized as TYPES OF COGNITIVE ERRORS ARE CONTAMINATION BY DEPLACED BODILY GARBAGE PRODUCTS IN SPECIFIC THERMODYNAMICAL PHASES.

This thermodynamical schema is also related to a velocity-schema, giving rise to expressions like the following:

“Hun er så langsom” (“She’s so slow”)

vs.

“Hun er et kvikt hoved” (“She’s a quick head”)

vs.

“Hun er forvirret” (“She’s confused”, literally, “She has shaken [her head] too much”)

The Danish prefix, unstressed “for -” (corresponding to German “ver -”) indicates a radicalization of the state indicated by the root, most often a worsening. One who is “forvirret” is hence one who has “virret”, shaken her head too much - one who is “lidt for kvik” (“a bit too quick”) as the saying also goes. This metaphor indicates a normal stratum localized between on the one hand a stratum in which mental processes go too slow and on the other hand one in which they develop too fast for stable results to be possible. The metaphor seems to rely on an ideal conception of a thought process as a having a certain velocity for a while, until it settles down onto a result: in the first phase this result is only slowly obtained or never reached; in the second phase it is reach in an acceptable time or even fast; in the third phase it is never reached, now for a new reason, because the process never settles on a result but keeps on changing between several metastable candidates. For a thermodynamical point of view, the relation between the phase schema and the velocity schema is made possible by the fact that phases microphysically are determined by the velocity of molecules, a knowledge which seems, to some degree, to inhabit ordinary language in

these metaphors. Also etymological arguments seem to support this, for instance in many German languages “quick” (Da. “kvik”) and “liquid” (Da. “vædske”) are related.

These schemas, in turn, seem to be related to yet another one concerning the complexity of the processes involved:

“Han har ikke ret mange brikker at flytte med” (“He’s not got very many pieces to move around”)

vs.

“Han har rotter på loftet” (“He’s got rats in the attic”)

[Eng. variation “Scatterbrain”]

“Hun har roterende fis i kasketten”

(“She’s got a rotating fart in her flat-cap”)

The latter expression combines thermodynamical phases, velocity, and complexity with deplaced bodily products: there are too many, hasty and malplaced pieces to move around; they do not stop to form stable patterns. “Rats in the attic” are not only unpleasant animals, but also a set of ungoverned partial processes. “Scatterbrain” lets the very brain or its processes be disseminated, here the set of pieces are disorganized. The expression “at have en skrue løs” (“to have a loose screw”) may be related to the same patterns: here there is so to speak one (deplaced) piece too many to move around. The very concept “skør” (“crazy”; literally, “fragile”) might in this respect be based on the insight in the fact that processes with many components are often computationally irreducible and hence need only a small push to move away from a fragile equilibrium and into another and less pleasant type of behaviour.

I shall now propose one single schema lying behind these various phase/velocity/complexity-schemas in the metaphors of folk psychology: the structure of the behaviour of cellular automata. This behaviour falls - according to Stephen Wolfram - in four typical classes as follows:

1. The automaton moves towards a point attractor, that is, after some time it settles onto one state and ceases to change. All initial conditions (of a certain class) lead to the same final state and are thus “forgotten”.

2. The automaton moves towards a cyclical attractor, that is, after some time it settles onto a shorter or longer circuit and repeats the same series of states endlessly. The final state is only dependent on a part of the initial state.

3. The automaton does not move towards any simple attractor, but forms long, so-called quasi-periodical patterns of high complexity with some (but never perfect) repetitions. The final state (at any given moment) depends on a still growing part of the initial state.

4. The automaton does not form any stable patterns at all, characterized by general computational unpredictability (even if the same initial state gives the same result every time, in so far as the automaton is deterministic). The final state (at any given moment) depends on changing parts of the initial state.

What is interesting in this typology of behaviours is the distribution of the four types. The boundary between the first and the second type is clear-cut and unambiguous; the boundaries between the other three are more fluid, in so far as 3) is in fact a borderline case between 2) and 4) which is hard to determine. In the final analysis, it might be very hard to determine whether an empirical behaviour belongs to 3) or 4). This taxonomy of behaviours of cellular automata is to a great extent homologous to the classification of attractors for dynamical systems (which, in opposition to the discrete cellular automata, are continuous). Here one can distinguish a case 0), classical mechanical systems, where no friction and development of heat occur and which hence are characterized by total conservation of energy - and whence the system does not move towards any stable state at all. After this, four classes of thermodynamical systems follow, all of them dampened and hence possessing attractors. They range from simple point-attractors over cyclical attractors and quasi-periodical attractors to "strange attractors" - analogous to the automata. After these cases one must add a fifth case, the so-called ergodic systems, thermodynamical systems with no attractors, involving all possible states over a very long period (f. inst. molecules of a gas which by the ergodic hypothesis are supposed to assume any possible combination of position and velocity in the course of time.)

Now, Wolfram's argumentation goes as follows: a subset of type 3) behaviours have properties making it possible to interpret them as universal Turing machines, that is, following the Church-Turing hypothesis of computer science they may implement any effective computation. Among one-dimensional automata, this behaviour is widespread, even if it is rare among two-dimensional automata (Wolfram, p. 478). In an interesting paper (1990), Christopher Langton takes this idea further and proposes the idea that naturally occurring computation in general must occur in systems "at the edge of chaos", that is, in systems which thermodynamically are in a state belonging to type 3) - formally analogous to the phase transition between solid and liquid phase. Langton hastily speculates further: another implication might be that the origin of life must have taken place in such a phase transition in the dynamical process of a complicated chemical system, thereby placing a new set of formal constraints on the state of the

“primordial soup”. Langton emphasizes that the potentially “intelligent” type 3) is subjected to the well-known halting-problem of computer theory. All universal Turing-machines are subjected to the limitations of the halting-problem: there exists no general procedure to decide whether a given program with a given input will ever finish its computations. As a generic subset (this is Wolfram’s idea) of type 3) cellular automata are universal computers, they must also be subjected to this condition: it is undecidable whether they, after a certain, maybe very long time, will “freeze” into a simple class 1)/2)-behaviour, stay in class 3) behaviour or they will settle onto chaotic class 4)-behaviour. Accordingly, Langton proposes a natural and more general equivalent to the halting-problem, his so-called

“ ... Freezing-problem: for an arbitrary cellular automaton in the vicinity of a transition point, will the dynamics ultimately “freeze up” into short-period behaviour or not? It is quite likely that the freezing problem is undecidable.” (33)

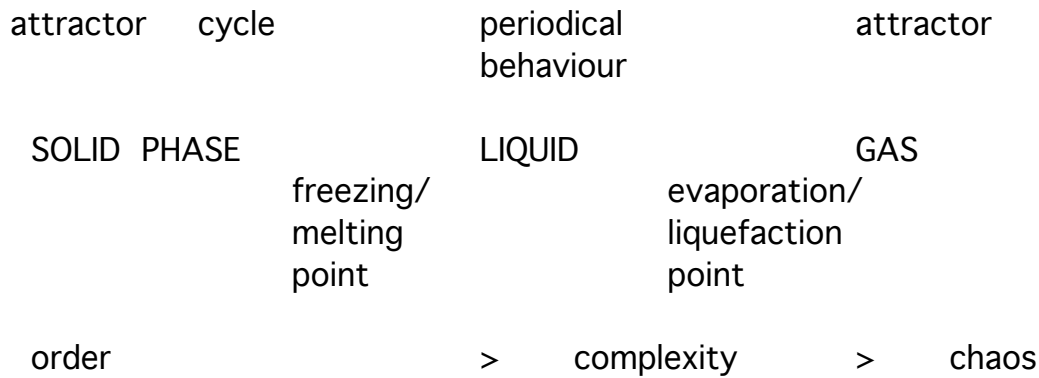
The very special natural systems able to compute must thus be able to preserve this state 3) between 1/2) on the one hand and 4) on the other, between solid and liquid phases, thus maintaining a transitory state of very long expansion. Langton further states the idea that the general “liquid” phase for cellular automata may be further distinguished into a liquid phase proper and a gaseous phase, just like the case in thermodynamics. (35)

The general consequence of this investigation of the behaviours of cellular automata for our problems of metaphor theory are rather apparent in the conclusions of Langton:

“... above a certain level of “complexity”, the process of synthesis is also degenerative. In other words, we find that there exist an upper limit as well as a lower limit on the “complexity” of a system if the process of synthesis is to be non-degenerative, constructive, or open ended.” (36).

There seems to exist a computationally fertile intermediate position between too low complexity (1/2)) and too high complexity (4)) (- here using the well-known identification of complexity with disorder in information theory and cybernetics). Complexity in everyday use of the word understood as functional complexity (an ability to undertake a plurality of processes) is thus rather a property in a certain subset of the intermediate zone between order and disorder, between high and low cybernetical complexity. This gives us a schema over the behaviour of cellular automata as follows:

| | | | |
|---------|---------|---------|---------|
| class 1 | class 2 | class 3 | class4 |
| point | limit | quasi- | strange |



- and, with the application of the schema onto the semantic domain of mental competence discussed above:

| | | |
|-----------|-----------|---------|
| STUPIDITY | NORMALITY | MADNESS |
|-----------|-----------|---------|

Now, this schema obviously does not possess the intuitive simplicity as a Gestalt, as do most of the “kinaesthetic image-schemas” of the Lakoff-school (container, source-path-goal, up-down, etc.) - but still many things argue for considering it as a candidate to this series of basic schemas. As is evident, the schema does not constitute a simple continuum dissected into three parts more or less arbitrarily; there is a important asymmetry in its articulation having its root in phase theory, according to which the decisive phase transition is the one between solid and liquid phase, distinguishing the value 0 and positive for the degree of freedom for the single particles - while liquid and gas are subarticulations of the general liquid category (cf. the phase schema for water showing that the distinction between the two disappear by sufficiently high pressure when water and vapour pass continuously into each other). In the domain of mental behaviour, this is reflected in the semantically more decisive and sharp difference between stupidity and normal intelligence - in contrast to the much more difficultly decidable boundary between normal intelligence and madness: if you are not a little mad, you will easily be considered boring, and the close connection between creativity and genius on the one hand and madness on the other (cf. “brainstorm”) is common folklore in many cultures, cf. the European stereotype of the “mad scientist” (Le professeur Tournesol, Dr. Strangelove etc.). Another stereotype in this connection is the “mad artist”, often less dangerous than the mad scientist, but equally crazy. These folk theories link artistic and scientific creativity with madness understood as frequent deviation from normal practices, of which only certain lucky hits actually serve art or science, while other less lucky deviations remain as pure madness, be it in everyday or clinical amounts. One can venture the hypothesis that these folk theories might not be completely mythological or arbitrary; maybe some of the various instatiations of the schema display basic (but of course not detailed) insights in types of brain behaviour which

further neurological research might validate and sophisticate?

In Lakoffian optics, an alternative status for the schema might be proposed, namely as a so-called “idealized cognitive model” which is a more complicated composition of several metaphors into a more specific and detailed conception of a single domain. An empirical argument for the schema being a schema rather than an idealized cognitive model is the fact that it seems to reoccur as organizing gestalt within wholly different domains besides the semantical domain of mental behaviours. Take for instance an explosive domain like ethnic identity where we find expressions as the following built on this schema:

“ bondeknoald” (Danish “bonde”, peasant, and “knoald”, lump - ‘lump of peasant’). “Bonde” is in fact derived from “boende”, dwelling)
“ the Aric German” (and his “Bodenständigkeit”)

vs.

“ rodløse existenser”, der “ikke kan falde til ro”
 (“rootless existences” which can not “settle down”)
“ Der ewige Jude”, ”cosmopolite”, ”dandy”, “flaneur” etc.

In the modern age, it is often seen as normal to enjoy some time in the latter part of the schema during some Wanderjahre before settling down somewhere in the middle. Where, in the mental behaviour domain, the decisive feature was the number of pieces (the heat, the velocity), it is here the trajectory (of a person, a nation or the like) through the phases which is central. Like in the mental domain, there is an implicit, ideal trajectory, finally settling on an attractor, but not before having taken a sufficiently long journey since the starting point. Technically, this narrative ideal model requires a superposition of the schema with the Lakoffian oriented trajectory schema of source-path-goal, letting the goal lie somewhere (in the upper end) of the intermediate zone.

A closely related semantical domain is sexuality, where the schema is apparent in constructions about women like

| | | |
|-----------------------------------|---|--|
| | “ skat” (darling; literally 'treasure') | “vandrepokal” (‘challenge cup’) |
| “ surt ribs” (‘sour currant’) | “godte” (sweetie) | “forsuttet bolsje” (‘sucked sweet’) |
| “ kold”/”frigid” (cold/frigid) | | |

problematic point in Lakoff's theory, a relation which is highlighted by the thermodynamical schema. On the one hand, the praxis-phenomenological aspect of the embodiment hypothesis implies that the Lakoffian schemata should be known from bodily practices, that is, they always appear in a specific source domain tied to the body. On the other hand, Lakoff has the idea of certain "generic" metaphors which are different from more specific metaphors by lacking any specific source domain (cf. the contrast between LOVE IS A JOURNEY and AN EVENT IS AN ACTION). This last type of metaphor with no privileged source domain deals with, according to Lakoff, a level of domain neutral "ontology" - but if this type of metaphors are possible, then schemas are potentially loosened from their emergence-like binding to specific domains, even if Lakoff in a Nietzschean intuition sees the "generic" metaphors as secondary, derivative abstractions. The thermodynamic phase schema is of course known from a range of everyday practices involving phase transition, cold, heat, weather, order, disorder etc. which constitutes a very potent set of source domains for the poetical (and general) imagination, cf. Bachelard's "l'imagination élémentaire" taking its departure in the four elements. In these practices we most often do not recognize the underlying schema (which, unlike Lakoff's other schemata) is only now being researched in qualitative dynamics, cellular automata research and complexity studies. The fact that there is not in this case one well-defined source domain thus seems to make of the schema a "generic metaphor" on a par with AN EVENT IS AN ACTION, but how should the conceptual metaphor be coined? "A TYPE OF BEHAVIOUR IS A THERMODYNAMIC PHASE"? In spite of the omnipresence of the schema it does not possess the immediate evidence of the traditional Lakoffian schemata. Yet another possibility, of course, is to relegate it to the second basic category in Lakoff's theory, the so-called "basic-level categories", so that the schema should be acknowledged as basic because of its evidence for the body which must learn to deal with phases and their interrelated behaviours. The schema, on the other hand, is so general, formally articulated and loosened from specific practices that it does not look like the average inventory of basic-level-categories.

What is it, then? Is it an image schema, a basic category, or an idealized cognitive model? I guess Lakoff after all would categorize it as an example of the latter, but I have a hard time not categorizing it as one of the former. Above, we went through a structural argument, to this, one could add a phenomenological argument: the various incarnations of it in differing source domains (temperature, order, velocity, phases) have the character of Husserlian *Abschattungen*, aspects, of the schema as ideal object.

If one did so, what would be the consequences for Lakoff's theory? It would be forced to further reflection of the idea of "embodiment". How does the schemas, in fact, emerge from the body? Is it the case that every conceivable body must possess knowledge of thermodynamical phases, in so

far systems able to computation must necessarily be realized in a dynamical system of Langtonian type 3) “on the edge of chaos”. If so, it is realized on a thermodynamically pregnant boundary where the “freezing problem” is indecidable and where problem solving is a case of “freezing” of the mind’s activity after a sufficient long thermodynamical trajectory. And if so, then (some) knowledge of thermodynamics is a priori necessary for any conceivable intelligence, and then Lakoff’s “experientialism” and transcendental agnosticism must be given up.

The schema, as noted above, is also very illuminating with respect to the intricate relationship between domains and schemas. In Lakoff, it is very often more or less implicitly assumed that the domains are ordered so that the more practice-related domains precede the more abstract ones so that inventory from the former can be projected onto the latter in order to understand these latter. It seems very natural to assume that thermodynamic phases ontogenetically constitute a very early experience, but does it follow from this that the phase domain is more primitive than the ethnic domain onto which it may be projected? A beloved Lakoffian example like LOVE IS A JOURNEY could seem to argue for quite the opposite. It might be said that in this metaphor, we understand the complicated (love) through the less complicated (journey), but it hardly gives any meaning to say that traveling is an ontogenetically or bodily more basic type of practice than love. The fact that certain schemas occur with evidence and cognitively easy to grasp in certain domains (as does source-path-goal in traveling) is not necessarily any argument for these domains’ practical and bodily preeminence. The schemas, then, are not intrinsic to domains, they are formally conceivable beyond domains, even if they are of course only realized within them, so to speak emerging out of the specificity of the domain (the thermodynamical schema is thus realized in phases, temperature, velocity, complexity - and from these source domains it may, in turn, be mapped onto mental, sexual, ethnical and other behaviour. But its formal stability as a schema precedes its various incarnations in source domains). If this is correct, the schema has the character of formal ontology in a Husserlian sense of the word, a formal ontology comprising a large class of systems consisting of many components - and hence it becomes an argument for the presence of synthetical a priori structures within Lakoff’s theory. Therefore, we might say that the tendency of certain domains to play the role of more primary than others is an empirical and hence variable fact which would also explain the strange mixture of widely different semantic sources in the domain of domains: from basic metaphysical properties (space/time, be it properties of the world or of intuition), to sense modalities (colours, forms, sounds etc.) and to more or less natural (sex) and cultural (traveling) practices.

The empirical knowledge of thermodynamics - be it a priori underpinned or not - and the various folk theories in thermodynamical

metaphors are of course not formalized, but the combination of high generality and high complexity in the schema seems to challenge Lakoff's theory in yet another way. If the schemas are really schemata in a Kantian use of the word, then their status as images are not sufficient to determine them, a symbolic determination is also necessary. Lakoff explicitly tries to avoid this, arguing that symbolic logic in itself may be wholly derived from image schemata. The necessary symbolic determination may be easily overlooked in Lakoff's more simple schemata because they appear so self-evident and seem so easy to grasp for the mind. Here, the thermodynamical schema is different, because it is much more complicated and even to this day not thoroughly mapped; this is only being done by further formalizing investigations (and not by any purely intuitive seeing). The thermodynamical schema thus makes evident the necessary symbolical determination of image schemata.

This last point has yet another interesting implication: even if understanding is schematic, then it does not necessarily have to be aware of any single detail or any single implication of the schema in use. The thermodynamical schema is not yet known in all its implications which are currently among the chief concerns of qualitative dynamics, far-from-equilibrium-thermodynamics, complexity theory, etc. - but in spite of this it seems to be widely known and used. One part of it, metaphors with weather source domain, is among the most central in poetry. It is illuminating here to think of Peirce's definition of the icon as a sign - the sign from which it is possible "to learn something more" - and correlatively his statement "But the icon is not always clearly apprehended." (8.467). The schema analyzed appears as a product of the meeting between intuition on the one hand and symbolic formalization on the other, a meeting still under elaboration. This lies already in the Kantian definition of the schema - but a decisive phenomenological correction to this idea is that as a prerequisite to this process of formalization, analytical detailing, and control of the schema, primitive versions of it must occur as spontaneous syntheses, as Cassirerian "symbolic pregnancies", appearing as primitive Gestalts to the mind. They are, of course, unsufficiently grasped, but this does not prevent their a priori status nor the everyday use of them, constituting a part of the uncovering of them in the long civilisatoric process of crystallisation.

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