CHAPTER 5

EVERYTHING IS TRANSFORMED

Transformation in Semiotics

Rien ne se crée, rien ne se perd, tout se transforme.

Lavoisier

Transformation procedures are crucial to diagram understanding. Traditionally, however, the notion of 'transformation' has not played a central role in semiotics. If we check the main semiotic dictionaries and encyclopaedias, the article in Sebeok 1986 under that word mainly deals with Chomsky's transformation grammar, while the notion does not appear as the headline of a separate article but is only put to use *en passant* as an auxiliary notion in the description of certain theories.[126] In the otherwise more idiosyncratic dictionary of Greimas (1979) presenting mainly the concepts of Greimas' own theory, the notion surprisingly receives the broadest treatment with reference to its origin in European comparative linguistics and its mathematical use, primarily in the US. Greimas's subsequent description loosely hints at some general ways of using the term in semiotics, even if, as could be expected, its use in Greimassian semiotics (to which we shall return below) plays the main role.

Our hypothesis here is that these sins of omission tend to hide the decisive and central role played by transformations in semiotics in general. Our aim here is to outline its use in different semiotic fields and theories – to provide a brief overview over the possible roles and tasks which it has – or ought to have.

If we go to the history of semiotics,[127] the term 'transformation' is most openly central to exactly Chomsky's generative grammar with its idea that one and the same deep structure may be transformed to a set of different, cognate surface structures by means of a set of transformation rules. Transformation holds a prominent position, moreover, in Lévi-Strauss's brand of structuralism (even if here being subject to less explicit investigation) with its idea that a myth may be transformed into other, related myths by the transformation of structure, measured in relation to a reference myth, in principle arbitrarily selected. Lévi-Strauss himself refers – which is only taken up by rather few of his many disciples – to the Scottish biologist d'Arcy Thompson who early in the twentieth century tried to found a theoretical, morphological biology built on the notion of transformation. Inspired, among others, by both Lévi-Strauss and Chomsky, Greimas's semiotics takes up the concept, now under the notion of 'conversion', it being the procedure which takes its point of departure in simple deep semantics and develops that into realized meaning via a series of intermediary steps. A certain interest here is deserved by the narrative level where can be found the notion of ‘narrative schema’, involving the idea of a general regularity in the temporal process of texts, connected to concrete, empirical texts by transformation. In recent semiotics, transformation plays a main role in the systematical picture semiotics of Groupe μ, while cognitive semantics and linguistics as central procedures under different notions claim transformations (‘mapping’ and ‘blending’ of conceptual or mental spaces), just like transformation in the main inspiration of this current, the cognitive psychology of Eleanor Rosch, plays a main role as that procedure which connects the prototype of a semantic category with different, less typical instantiations of it. In the diachronous linguistics of the nineteenth century, a central transformation problem resides in the idea of sound laws as the nexus of linguistic development.

On the other hand, it is striking that no prominent concepts of transformation are to be found in most of European structuralism and structural linguistics, the Saussure-Brøndal-Hjelmslev-Eco lineage. Here, the exception is the theoretically not very explicit Jakobson (e.g. in his idea of a projection between the two main axes of language). In Peirce, such as he has become popularized as a taxonomist of signs, transformation might not seem central in a first glance, but a closer investigation finds transformations in the heart of his semiotics, namely in diagrammatical variation and the abstraction procedures facilitating diagrams. In Husserl’s semiotics and phenomenology, the transformation concept explicitly plays a central role, first in the variation of profiles in the phenomenology of perception (where the continuous transformation of one *Abschattung* into another grants the unity of the object perceived), second in the idea of a cognate procedure on the ideal level in the concepts of *Wesenserschauung* where the eidetic variation finds the identity of an ideal object on the basis of the transformational possibilities of an empirical example. A related idea, more formalized, is to be found in Cassirer and his formalization of perception on the basis of group theory: an object perceived is defined by invariance in a group of geometrical transformations.

As might be evident in this list of semiotic concepts of transformation, there are certain recurrent sources present: mathematics, biology, linguistics. The former because here the formal treatment of various types of transformations (function, mapping, variation, etc.) may be found which may then be put to use in the empirical field of semiotics; the next because semiotics as an empirical science is often rooted in the more basic and comprehensive science covering those living beings having access to meaning; the latter because language is often taken to be a privileged and fundamental semiotic system. These three sources of inspiration are not parallel, now, mathematics is purely formal, general and a priori (without involving here the large infights of philosophy of mathematics, I just mean a priori as valid prior to empirical application) – while biology and linguistics are empirical sciences which to the same degree as semiotics (and other empirical sciences) must use mathematical formalisms, whether implicitly or explicitly, but both of them share some of the regional ontological prerequisites to semiotics as an empirical science.

As to the former, both Husserl and Peirce, qua practising mathematicians, had a direct interest in mathematics which inspired the variation type concepts of both – based on the mathematical concepts of function or mapping as the procedure taking one object into another.[128] An influential version of the concept of transformation is to be found in Felix Klein in his famous Erlangen-program which systematizes different geometries depending on which transformations leave their objects invariant, and more generally group theory as a formal concept for sets equipped with different procedures taking elements into other elements belonging to the set. In our days, a further development is category theory, generalizing the transformation concepts of different mathematical sub-disciplines to the notion of arrows between objects (as generalized functions) and adjungated functors operating between whole categories (thus providing of meta concept of transformation between whole subsets of mathematics: arithmetic, set theory, group theory, topology, etc.).

To the extent that biology is counted among the sciences of meaning (cf. 'biosemiotics', e.g. Sebeok 1992, see Chaps. 9–12) and the discussion of the ongoing use of meaning categories even down to biochemistry ('genetic information'), various transformation concepts of biology also inform semiotics, thus the metabolic cycle as basic for semiotic intention (Thom 1975, Uexküll 1982), the transport of information in genetics, epigenesis as transformation procedure in 'developmental' biology – but also the concept of mutation in the theory of evolution. Even if mutation often plays the role as an arbitrary basic concept which cannot be further explained (as an error in transformation), a rational explanation is sought in the actual complexity theory (The 'Santa Fe'-school, Kauffman, Goodwin, etc.) which reference back to d'Arcy Thompson and the 'rational morphologies' of the nineteenth century. Thus, there seems to be a connection between whether a biological theory involves a notion of transformation (in addition to causal concepts) and whether that theory recognizes a meaning concept in biology. In many actual semiotic theories, biological foundations often play the role of yet uncovered limit condition (the inneism of Chomsky, Lévi-Strauss's idea of the universals of human cognition in neurology, Greimas's reference to a 'natural world' prior to semantic investment, the body concept of phenomenology and, correlatively, the 'embodiment' notion of cognitive semantics) – the actual neurobiological research may be expected to achieve a large semiotic relevance in the more detailed investigation of these spontaneous ideas. In general, though, biology as a theoretically articulated science remains split into subdisciplines to such a degree that its explicit reflections on its formalisms used do not seem much more developed than semiotics.

Much more could be mentioned than this list of examples: transformations and the transformation of transformations pop up in many forms and in some sense it is strange that the discussion of the central status of the transformation concept in semiotics has not begun long since. Several reasons may be given for this striking omission. One is the general phenomenological rule that evident phenomena may be hard to make explicit. Another reason – more in the history of science – may be that European semiotics with its roots in linguistic structuralism has often, lead by Saussure's methodological distinctions between synchrony and diachrony as well as *langue* and *parole*, tended to see static structures as having ontological prominence over their transformations and thus has been interested primarily in 'codes' seen as stable relations between content and expression. The very concept of the *sign* may thus, paradoxically, have hindered the insight into the centrality of the concept of transformation. If the colocalization of expression and content are taken as central or essential, then the transformation of expressions, of contents, or holding between the two of them may be relegated to the periphery of semiotic investigation. The distinction between diachrony and synchrony in Saussure has often, in this tradition, been taken as an ontological barrier privileging synchrony over diachrony – and, furthermore, the place of synchronous description in the middle, between diachronous linguistic development on the one hand and linguistic use on the other has split this structuralism into two concepts of time without mutual contact and both ontologically underweight, with the often-noted implication that diachronous system change as the result of changes in use tends to become invisible. Correlatively, much criticism of this tradition – cf. post-structuralism – has referred to the transgression of those 'static structures', but then most often in an irrational vitalism referring to a deep, ungraspable movement which are not formally grasped as a transformation. Within linguistics, the focus upon use has given rise to the various pragmatical traditions sensitive to changes in linguistic usage, but then often in versions having little interest in the structural character of sign systems. These developments constitute, of course, part of the 'transcendental Jalta' diagnosed by Jean Petitot in twentieth century philosophy and science, between logical atomism and reductionism on the one hand and vitalist irrationalism on the other; in this tragic split, the notion of transformation seems a victim which is either reduced away on the one hand or mystified into a dynamic deep ontology beyond scientific reach on the other.

The field covered by semiotics is indeed vast, and there is no reason beforehand to assume that the transformations involved, not to talk about the theoretical tools needed to study those transformations, should be identical nor simple. For this reason we must approach the question in a so to speak botanical way and try to achieve an overview over the most important concepts of transformation used in the semiotic sciences as they are evolving. I do not claim the list of transformation ideas below to be exhaustive, but I hope to have picked a series of central and typical versions.[129]

LÉVI-STRAUSS: TRANSFORMATION AND STRUCTURE AS INTERDEPENDENT CONCEPTS

Claude Lévi-Strauss (1971, 73, 74, 88) is probably the scholar in semiotics, broadly taken, in whom the concept of transformation occurs most explicitly. Even if his formalizations most often take place ad hoc and are not tied to precise definitions nor consistent relations between the different formal subtypes,[130] transformation has a crucial place in his definition of structuralism. Lévi-Strauss is, of course, anthropologist and so to speak a practician comparing myths by transformation without first making those transformations explicit. The central idea lies in the assumption that it is the *narration* of a myth which provides its core – and this narrative structure can be understood only in comparison of the myth with other myths. This comparison is possible only by transformation: the myth is transformed into neighboring myths, cognate myths, etc., and only the location of the myth in this landscape of transformation decides its content. A myth, thus, consists of a group of variants. In this view, the concept of structure is solidary with the concept of transformation: it is meaningless to claim that a single myth 'has' a structure – a structure being a pattern only discernible in relations of variance and invariance by transformation between several myths – a structure only exists as realized in a multitude of related objects. Lévi-Strauss only rarely expresses this idea as directly as in the late interview volume (1988): 'But the notion of transformation is inherent in structural analysis. I would even say that all the fallacies, all the abuse made to or with the notion of structure come from the fact that their authors have not understood that it is impossible to conceive of the notion isolated from transformation. Structure cannot be reduced to system: a set of elements and the relations which unite them. To talk about structure, it is necessary that there are invariant relations between the elements and relations of several sets, so that you can pass from one set to the other by means of transformation.'[131] In this context, it is important to point out that the concept of transformation is open to both synchronous and diachronous investment – it refers to the structural relation between myths as well as to their possible origin and genetical family relations. Which myth is chosen, in the single case, as 'reference myth' is the choice of the investigator based on pragmatical considerations – an idea solidary with Lévi-Strauss' empirical work: the general deep structure of myth is an invariance of all possible transformations and thus not localized in any particular object. In a history of science context, it is interesting to note that Lévi-Strauss's concept of transformation does not at all stem from structural linguistics – which it is normal to assume to be his main theoretical source of inspiration outside of anthropology, just like the source of his preference for dual opposition structures in his friend Jakobson. His transformation idea, quite on the contrary, explicitly stems from d'Arcy Thompson to whom we shall return below.

It is interesting to remark that transformation in Lévi-Strauss seems to be prerequisite to the concepts of identity and difference: the identity of a myth is constituted as a group of variants (understood as variants due to transformation) – but at the same time one such myth relates to neighbouring myths due to specific transformations. Thus it is transformation which forms the basis of identity and difference on the level of myths – and there seems to be a continuum between the two because the delimitation of variants of 'one' myth and variants of another depends upon the generality of the transformation chosen. A further important consequence is that the concept of transformation refers to organized wholes (myths – more generally, gestalts, patterns, schemata, etc.) – structure resides in several, comparable organized wholes. Interesting in our context is also the fact that the concepts of transformation and structure are here related to a concept of abstraction of a non-inductive kind: 'Regarding comparative method, I have often said that it does not consist in comparing first and generalizing afterwards. Contrary to what is often believed, it is generalization which founds and makes possible comparison.'[132]

D'ARCY THOMPSON AND THE PRIMACY OF CONTINUOUS TRANSFORMATION

D'Arcy Wentworth Thompson is probably considerably less known than Lévi-Strauss; he was a Scottish 'naturalist' or theoretical biologist in the beginning of the twentieth century. His scepticism towards Darwinism notwithstanding, his general idea was to study biological form in a sort of phenomenological bracketing of the yet unknown – then even more than today – precise biochemical processes underlying them. The relative simplicity of macroscopic biological form allowed for a purely morphological science of biological appearance[133] which might, inter alia, investigate the question of *scale* of biological phenomena (originally Galileo's idea), and which prompted the construction of a doctrine of transformations ('On the Theory of Transformation, or the Comparison of Related Forms') where he was able to take one and the same bone form, organ form and in some cases the whole body shape in related species and demonstrate elementary, continuous Cartesian transformations holding between them. On the other hand, such transformation is possible only between related species being variations of one and the same type – they may never connect completely different *Baupläne*. D'Arcy Thompson thus is a partisan of natural morphology. Very illustrative – also in relation to the discussion of scale – is his'derivation' of the same bone structure in ox, sheep, and giraffe by a simple shortening of scale in one dimension and a logarithmic contraction in another (277):

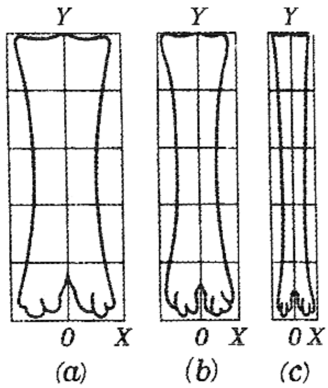

Figure 14. Structural similarity between foot bone structure in (a), ox (b), sheep, (c), and giraffe

Most famous – thanks to their illustrative evidence – is his morphololgies of different fish species where he introduces radial coordinates (ill. 149, 151). A corresponding treatment of skulls of horse, rhinoceros, and tapir does not yield the same degree of detail correspondence (they are more remotely related), and

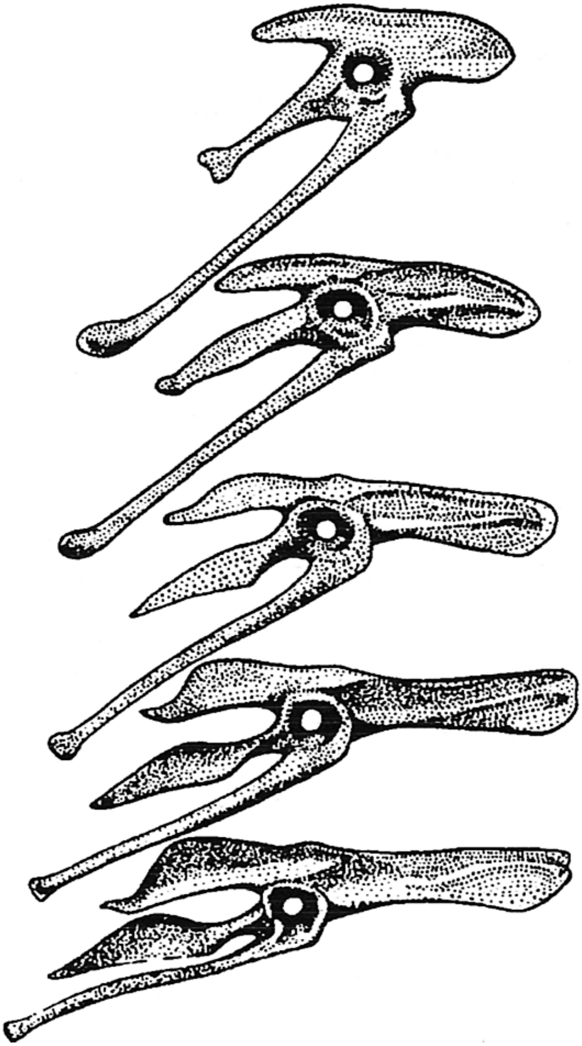

Figure 15. Pelvis from Archaeopteryx and Apatornis with three intermediate forms reconstructed by interpolation

yet – with the exception of certain details regarding eyes and dental positions – interpret the skull of a rabbit as a relatively simple bending (and diminishing) of the rhinoceros skull. There is thus an unspoken idea here that more general morphological similarities can be determined by the same type of transformation as the more specific ones, only with a increased tolerance towards detail deviance. With this basic idea, d'Arcy Thompson saw the possibility of theoretical reduction of the vast empirical biological complexity – at the same time this reduction permits the single species to maintain its specificity as the result of one specific transformation. By correspondence with the Danish draughtsman Gerhard Heilmann, he let produce a series of plates which tries to map intermediary forms between given morphological types, such as those (fig. 15) between the pelvis shapes in early birds (*Archaeopteryx* and *Apatornis* (309)).

From these immediately convincing diagrams, D'Arcy Thompson draws the quick conclusion that continuous transformation permits us to privilege the simplest transformation between two types and thus assume that they represent the real process of evolution connecting those types. Thus, he gives a rendering of the famous series of 'missing links' from the stipulated ancestral tree of the horse (the first such tree which seemed possible to sketch on the basis of paleontological findings) and compares it with the series of construed intermediary forms derived from a continuous transformation between the earliest known proto-horse *Eohippus* and to the *Equus* of our time. Several sources of error, however, are present her. Not only can we not assume that the empirical paleontological findings belong to one and the same line – several of them may, of course, belong to side-branches to the line leading to *Equus*. But, principally more grave, it is not in general the case that particular continuous transformations are unique, they are in general elements of a whole generic equivalence class of possible continuous transformations between the two forms (if not, the transformation would not be stable). In the horse example, this implies that there will be more than one possible route leading from the proto-horse to the horse, and we have no formal means for preferring any single one among them. These two things imply that we may not select one simple transformation and expect of evolution to have chosen exactly the same continuous series of transformations. Here, Thompson exaggerates the degree of information which can be extracted from morphological analogies. This does not, however, prevent his method from possessing a series of important properties: it compares morphology on the basis of the whole shape structure and not from singular, independent features (as did paleontologists in his time, e.g. in the comparison of human and ape skulls based on measuring size along a few axes). It constructs morphological classes on highly different levels of generality (cf. the rabbit example) determined by different transformations. It also provides an impression of the limits to morphological classification: transgressing the large animal groups in the animal kingdom, morphological transformation gives less meaning, because they pertain to wholly different *Baupläne*. It gives an indirect picture of the underlying complexity of transformations (the change of 'powers' forming the shape in question as he says with a deliberately vague notion). It introduces a phenomenological morphology category where structural classification becomes possible even if (potential) knowledge about the underlying causal dynamics is bracketed. Doing so, it provides a formalization of some of those 'inexact essences' of non-geometrical kind which Husserl referred to and which he – probably too hastily – condemned as inaccessible to axiomatic formalization.

A very important corollary to these continuous transformations is that they do not take an inventory of discrete elements as their basis (even if such elements may, of course, appear as their outcome) – which is why they allow that certain elements under certain transformations vanish completely. D'Arcy Thompson does not directly make this important implication explicit, but it lies implicitly in his observations regarding the small bone *interclavicus* in the *Ichtysaurus* which in the transformation to *Cryptocleidus* is 'minute and hidden' (305). In a continuous variation nothing prevents that a certain element can cease to be realized but which – knowing the transformation – may be said still to be *imaginarily* present (cf. next chapter) – an important fact because it demonstrates that the amounts of explicit large-scale elements in two shapes connected by transformation do not have to be identical – thus without this fact prohibiting the existence of such a transformation. Spontaneously experienced similarity (in the inventory of elements) hence does not count as a decisive criterion of the existence of a significant transformation between two phenomena. In discontinuous transformations, in contrast, a 1-1 mapping between elements would normally be expected and the lack of that possibility either as an indication of the non-relatedness of the two phenomena or as their difference must be explained by the addition of some explicit rule or reason.[134]

FELIX KLEIN AND THE ERLANGEN PROGRAM

Lévi-Strauss and D'Arcy Thompson have, each of them, sporadic references to the German mathematician Felix Klein and his work on the relation between transformation and invariance in mathematics. His famous, so-called Erlanger program from 1871, systematizes the bundle of different geometries of his time. The centuries of attempts at proving the parallel axiom of Euclidean geometry (given a line and point, only one line parallel with the given one may be drawn through the point) had produced the strategy of denying that axiom in the hope of deriving a self-contradiction as a proof of it. Instead, these denials of the axiom turned out to produce fully consistent, alternative geometries (Lambert, Saccheri, Taurinus, Gauss – formalized by Lobachevski, Bolyai, and Riemann) – namely the so-called hyperbolic and elliptical geometries, respectively (where infinitely many or none parallels might be drawn, respectively). At the same time, the so-called projective geometry was developed (Monge, Poncelet, Carnot) which, in contrast to the (non-)Euclidean geometries are not metric and introduced the principle of continuity (Poncelet) which allowed for the proof of general theorems for many different figures, even if some of the elements of the figures in certain cases became imaginary (Chasles) – cf. above how this principle plays an empirical role in d'Arcy Thompson. Cayley could now place metrical geometries as a subset of projective geometry. Klein's basic insight ('Vergleichende Betrachtungen über neuere geometrische Forschungen' (1872)) now was the fact that these different geometries might be systematized after which group of transformations each of them allowed for.[135] The aspects of objects each of them studied were interdependent with the transformations because the objects might be determined by invariance with respect to those transformations. In the Euclidean geometry, e.g. rotation, parallel displacement, mirroring in a line or in a point, (in short, 'stiff movements') e.g. are allowed transformations, because a figure remains the same when subjected to these procedures which keep shape, angles, size, etc. invariant. The group of projective transformations, e.g. is more general and gives rise to invariants as linearity, co-linearity, conic sections, harmonic sets of points (which, to be sure, also hold for the more specific Euclidean geometry). Klein's general classification had this character:

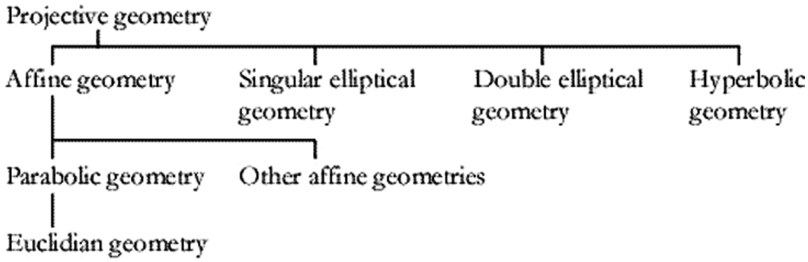

Figure 16.

even if he also determined even more general geometries, such as the algebraic geometry of the 'Cremona'-transformations, differential geometry leaving the second derivative invariant, and finally a geometry whose transformation group consisted only of different forms of inverse continuous mappings (so-called homeomorphisms): topology, the so to speak most general geometry where only invariants as connexity, compactness, open- and closedness, number of holes remain and

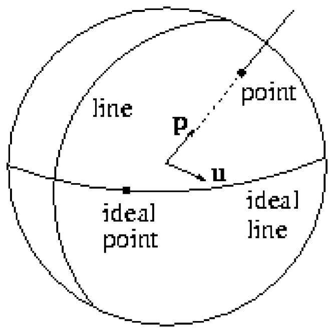

Figure 17.
Projective geometry may be considered as geometry of a sphere, projected from the center and onto a plane parallel to the equator plane and touching the sphere at the North Pole. Thus, all great circles on the sphere become lines in the plane – lines which end in ideal points at infinity of the plane – just like the projection of the equator becomes an ideal line at infinity. In projective geometry, several transformations are permitted which do not exist in Euclidean geometry, making, on the other hands, the correlated invariants fewer (Length, angle and ratio of lengths, e.g. cease to be invariant in projective geometry). This points to a general structure regarding transformations: the more identity preserving transformations allowed in a given diagram, the less invariants are preserved – and the more general those invariants which remain (such as topological invariants like connectedness and number of holes)

objects can be conceived independent of the space in which they are embedded. This classification has been further refined since Klein, and his endeavor is primarily relevant in our context because it provides the foundation for the idea that a vast and differing inventory of possible transformation groups (with each their corresponding inventory of invariant objects) can be made for the formalization of space. It is an open issue how many of these transformations have direct semiotic relevance but apart from Euclidean geometry there is a long tradition for pointing to the fact that various topologies due to their 'generalization ability' play a huge role in perception and language (cf. e.g. Leonard Talmy 2000; René Thom 1980).

The group of transformations characterizing each geometry may be formalized in group theory which opens up the possibility of a meta transformation where the optics may change by the changing of geometry and it becomes possible to signify one and the same object in different ways, because different invariances correspond to different properties – without this perspective shift dissolves the objectivity of the object in question. A figure with three straight edges is, of course, a triangle in Euclidean geometry while the same figure, topologically speaking, is a connected, 1-D manifold. Klein's duplicity of transformation and invariance thus allows, phenomenologically spoken, that the object's objectivity is maintained, while different acts pick out different aspects of it.

The concept of transformation in mathematics is explicitly tied to geometry as in Klein, even if the concept strictly taken is synonymous with the more general concepts of function and mapping. Transformations are thus also characterized by the different possibilities of describing a function. By a procedure (intensionally), by a graphical representation (intermediate between intensional and extensional), by correlated sets of points (extensionally). Extensional description is, of course, only possible to exhaust in finite, i.e. discrete, cases where the set of element pairs can be given explicitly. Intensional description by a procedure rule (e.g. $f(x) = \tan x$) in a certain sense comprises transformations of continua but suffers, on the other hand, from not being able to make explicit its extension (and thus not naturally state the field of validity of the function – e.g. that the given function has no value for $\pi/2$). As to graphical representations (which are continuous but suffer from imprecision and, in many cases, from being partial only), the main tendency in mathematics in the last century and a half has been to see them as heuristic tools only, which ought to be marginalized. Here, the actual interest in diagrammatic reasoning forms, of course, a counter-movement. Most transformations in semiotics take place without any conscious intention and explicit representation and it may for this reason be difficult to indicate preferred representation mode for them; maybe the mixed version could be expected to appear most often, even if the other two pure versions may also appear in different pragmatical contexts.

Let us from this preliminary triad of explicit transformationists in anthropology, biology, and mathematics look at a series of more implicit transformation concepts in mathematics (various aspects of qualitative dynamics) and biology (biosemiotics, complexity theory), cognitive semantics and linguistics (Lakoff, Turner), psychology (E. Rosch, S. Harnad), semiotics (Greimas, Groupe μ) as well as philosophy – Husserl, Peirce – in order to get an overview of the different semiotic role of transformations in these sciences.[136]

QUALITATIVE DYNAMICS

The most explicit influence from mathematics in semiotics is probably René Thom's controversial theory of catastrophes (1977, 1980), with philosophical and semiotic support from Jean Petitot (1985, 1992). Catastrophe theory is but one of several formalisms in the broad field of qualitative dynamics (comprising also chaos theory, complexity theory, self-organized criticality, etc.). In all these cases, the theories in question are in a certain sense phenomenological because the focus is different types of qualitative behavior of dynamic systems grasped on a purely formal level bracketing their causal determination on the deeper level. A widespread tool in these disciplines is phase space – a space defined by the variables governing the development of the system so that this development may be mapped as a trajectory through phase space, each point on the trajectory mapping one global state of the system. This space may be inhabited by different types of attractors (attracting trajectories), repellors (repelling them), attractor basins around attractors, and borders between such basins characterized by different types of topological saddles which may have a complicated topology.

Catastrophe theory has – cf. the general discussion of the Erlangen program – its basis in differential topology, that is, the branch of topology keeping various differential properties in a function invariant under transformation. It is, more specifically, the so-called Whitney topology whose invariants are points where the *n*th derivative of a function takes the value 0, graphically corresponding to minima, maxima, turning tangents, and, in higher dimensions, different complicated saddles. Catastrophe theory takes its point of departure in singularity theory whose object is the shift between types of such functions. It thus erects a distinction between an inner space – where the function varies – and an outer space of control variables charting the variation of that function including where it changes type – where, e.g. it goes from having one minimum to having two minima, via a singular case with turning tangent. The continuous variation of control parameters thus corresponds to a continuous variation within one subtype of the function, until it reaches a singular point where it discontinuously, 'catastrophically', changes subtype. The philosophy-of-science interpretation of this formalism now conceives the stable subtype of function as representing the stable state of a system, and the passage of the critical point as the sudden shift to a new stable state. The configuration of control parameters thus provides a sort of map of the shift between continuous development and discontinuous 'jump'. Thom's semiotic interpretation of this formalism entails that typical catastrophic trajectories of this kind may be interpreted as stable process types phenomenologically salient for perception and giving rise to basic verbal categories.

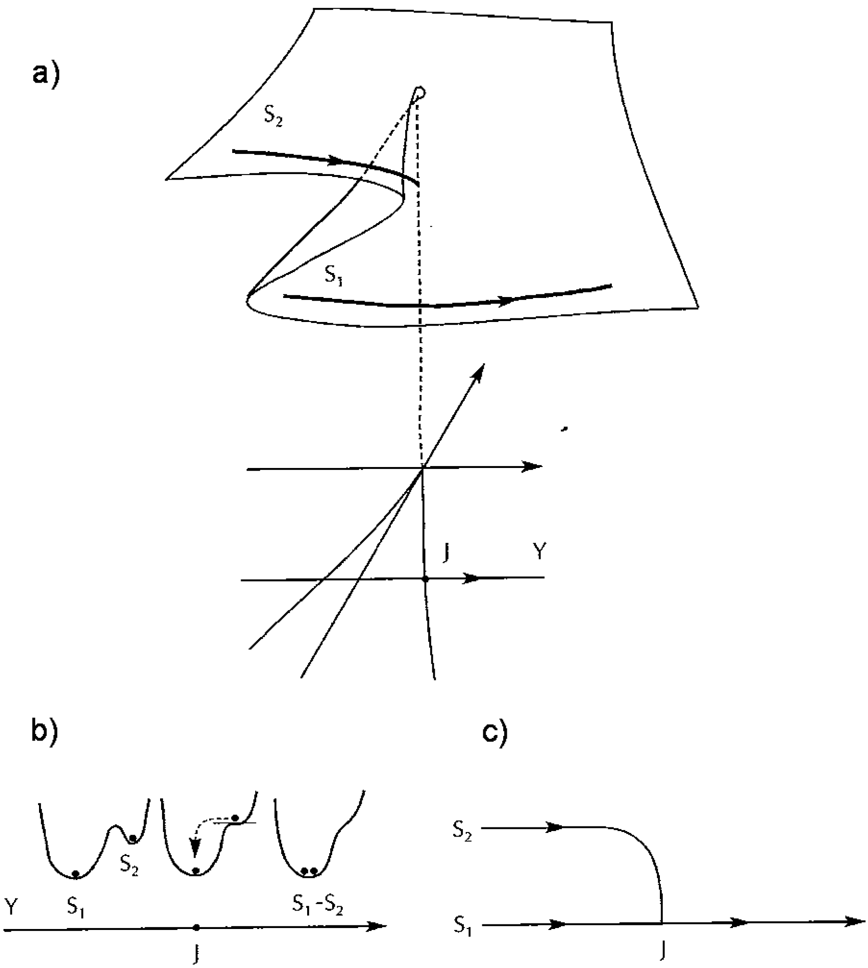

Figure 18.
One of the simpler catastrophes is the so-called *cusp* (a). It constitutes a meta-diagram, namely a diagram of the possible type-shifts of a simpler diagram (b), that of the equation $ax^4 + bx^2 + cx = 0$. The upper part of (a) shows the so-called fold, charting the manifold of solutions to the equation in the three dimensions *a, b* and *c*. By the projection of the fold on the *a,b*-plane, the pointed figure of the cusp (lower *a*) is obtained. The cusp now charts the type-shift of the function: Inside the cusp, the function has two minima, outside it only one minimum. Different paths through the cusp thus corresponds to different variations of the equation by the variation of the external variables *a* and *b*. One such typical path is the path indicated by the left-right arrow on all four diagrams which crosses the cusp from inside out, giving rise to a diagram of the further level (c) – depending on the interpretation of the minima as simultaneous states. Here, thus, we find diagram transformations on three different, nested levels.

The concept of transformation plays several roles in this formalism. The most spectacular one refers, of course, to the change in external control variables, determining a trajectory through phase space where the function controlled changes type. This transformation thus searches the possibility for a change of the subtypes of the function in question, that is, it plays the role of eidetic variation mapping how the function is 'unfolded' (the basic theorem of catastrophe theory refers to such unfolding of simple functions). Another transformation finds stable classes of such local trajectory pieces including such shifts – making possible the recognition of such types of shifts in different empirical phenomena. On the most empirical level, finally, one running of such a trajectory piece provides, in itself, a transformation of one state into another, whereby the two states are rationally interconnected.

We cannot here go further into the formalisms of catastrophe theory and their semiotic interpretation,[137] but suffice it to say that these three levels of transformations are interlinked, because the higher transformations take the lower as their objects, varying their conditions. Generally, it is possible to make a given transformation the object of a higher order transformation which by abstraction may investigate aspects of the lower one's type and conditions.[138] As an abstract formalism, the higher of these transformations may determine the lower one as invariant in a series of empirical cases (for Thom, e.g. the giving of a gift and in the structure of a sentence involving indirect object).

Complexity theory is a broader and more inclusive term covering the general study of the macro-behavior of composite systems, also using phase space representation. The theoretical biologist Stuart Kauffman (1993) thus argues that in a phase space of all possible genotypes, biological evolution must unfold in a rather small and specifically qualified sub-space characterized by many, closely located and stable states (corresponding to the possibility of a species to 'jump' to another and better genotype in the face of environmental change) – as opposed to phase space areas with few, very stable states (which will only be optimal in certain, very stable environments and thus fragile when exposed to change), and also opposed, on the other hand, to sub-spaces with a high plurality of only metastable states (here, the species will tend to merge into neighboring species and hence never stabilize). On the base of this argument, only a small subset of the set of virtual genotypes possesses 'evolvability' as this special combination between plasticity and stability. The overall argument thus goes that order in biology is not a pure product of evolution; the possibility of order must be present in certain types of organized matter before selection begins – conversely, selection requires already organized material on which to work. The identification of a species with a co-localized group of stable states in genome space thus provides a (local) invariance for the transformation taking a trajectory through space, and larger groups of neighboring stabilities – lineages – again provide invariants defined by various more or less general transformations (cf. d'Arcy Thompson). Species, in this view, are in a certain limited sense 'natural kinds' and thus naturally signifying entities. Kauffman's speculations over genotypical phase space have a crucial bearing on a transformation concept central to biology, namely mutation. On this basis far from all virtual mutations are really possible – even apart from their degree of environmental relevance. A mutation into a stable but remotely placed species in phase space will be impossible (evolution cannot cross the distance in phase space), just like a mutation in an area with many, unstable proto-species will not allow for any stabilization of species at all and will thus fall prey to arbitrary small environment variations.

Kauffman here takes a spontaneous and non-formalized transformation concept (mutation) and attempts a formalization by investigating its condition of possibility as movement between stable genomes in genotype phase space. A series of constraints turn out to determine type formation on a higher level (the three different types of local geography in phase space). If the trajectory of mutations must obey the possibility of walking between stable species, then the space of possibility of trajectories is highly limited. We shall return to Kauffman's semiotic ideas in Chap. 12.

Finally, self-organized criticality as developed by the late Per Bak (1997) belongs to the same type of theories. Criticality is here defined as that state of a complicated system where sudden developments in all sizes spontaneously occur. The prototype is boiling water where vapor bubbles of all sizes appear. Here, criticality is delimited to one, catastrophic point at 100 degrees centigrade. The prototype of *self-organized* criticality, in turn, is a sand pile rising from a continuous addition of sand from above. After some time, this pile reaches a maximum steepness after which any single new grain of sand may release avalanches on the side of the pile – the smaller the avalanche, the more frequently it occurs, and vice versa, size and frequency having a 1/f relation. This invariant property may be found in highly different systems sharing the property of such 1/f noise (widespread small, rarer larger events) and thus allows, parallel to catastrophe theory, a formal transformation of invariance between as different empirical phenomena as traffic jams, earthquakes, bourse cracks, extinction of species in an ecological system, Schumpeter 'creative destruction' in economics, etc.

These examples make evident a certain use of the concept of transformation which lay already in the Erlangen program, connecting it to the concept of form. Transformations identifies invariances: the fact that traffic jams, earthquakes, etc. all can be said to be self-organized critical systems is the same to say as that a related form may be found in all of them and thus may be mapped between them.

GROUPE μ – DOUGLAS HOFSTADTER

The Belgian group of semioticians Groupe μ in 1993 published what already stands as a new classic of pictorial semiotics, *Traité du signe visuel*. Here, they attack the linguistophile French semiotics of the 60s by involving psychological and cognitive research in the visual system, and one of the decisive concepts in their theory is exactly transformation. They introduce, on the characteristical third place between signifier and referent a meaning concept on the purely visual level named *type*, characterized somewhat diffusely by being a sum of visual paradigms (a head, in a paleo-Greimasian way, will then be composed of the marks superativity, roundness, closedness with the subtypes of eyes, ears, nose, and mouth . . .). The decisive step in our context, however, is that the verbal denomination of these features do not define them; they are types on the purely visual level (even if all of them, in the example given, have a denomination in natural language – far from all visual types necessarily have that). Such types are conceived as invariants in relation to a long series of possible iconical transformations, geometrical transformations (translations, rotations, displacements, congruences, projections, topological transformations, aggrandisations, diminishings), analytical transformations (various filters, continuisations, blurrings, differentiations, discretizations), optical transformations (changes of contrast or depth sensitivity, inversions), and kinetical transformations (integrations, anamorphoses). The decisive criterion here is that transformations stabilize the image as the type remaining invariant through transformations. It provides, in turn, for the possibility – cf. above – that these transformations are used inversely, resulting in a whole flora of *transformation rhetorics* whose effects can be investigated. Given, e.g. a head, it may be turned, filtered, discretizised, anamorphosed, etc. if it remains a type with a sufficient amount of redundant features to be recognized as such. Here, a crucial semiotic duplicity is evolved (which may also be found in Hofstadter): that possible transformations leave the type invariant (rather than define it), but, conversely, give it a series of variation possibilities to be used semiotically and aesthetically.

Douglas Hofstadter has analyzed related examples, e.g. in relation to designer typefaces (1986).[139] His question comes, so to speak, from the opposite side of Groupe μ's sender's point-of-view (seeing transformation as a rhetorical device), namely a cognitive receiver's point-of-view: how is it possible immediately to recognize a letterform, an A, e.g. given the enormous amount of very different and highly artificial designer typefaces we meet? Hofstadter runs through an argumentation for the fact that no computational algorithm is possible which may produce all possible As (thus, the A is yet another example of a Husserlian 'inexact essence'). The argument is an analogy to Gödel's theorem: a sufficiently complex formal system cannot be both consistent and complete. Analogously, no program to generate As can be both consistent (generating As only) and complete (generating all possible As). But the fact that such a transformation algorithm may not be constructed only gives transformation free reins to construct As in a trial-and-error process – thus Hofstadter sees this logical limitation as equivalent to a creative freedom explaining the fact that still new designer typefaces surprise the market year after year. The type A is defined by certain central characteristics, but they are not necessary and sufficient properties for the single As which may not, then, be defined beforehand. When the observer categorizes a strange designer A, he involves in a trial-and-error process as well (diacritically guided by the other letters of the same typeface, often appearing alongside it), whether it is possible to stably transform the apparent hieroglyph into a prototypical A. It may be expected that the single typeface is characterized by a specific set of such transformations. In this case, transformation defines identity: that is counted as an A which may be transformed to prototypical A. The transformative variation of prototypical As is thus also an ongoing investigation of the border areas of the type category. Here, transformation takes two roles, as in Groupe μ, it leaves types invariant and it opens up a stylistic field of variation possibility within that type. Hofstadter even extends the argumentation to artistic creation in general to be analyzed as 'theme with variations'. Analogies abound between Hofstadter and cognitive semantics, to which I shall return.

PARIS SCHOOL SEMIOTICS

The semiotics of Greimas also involves transformation concepts on several levels – the most explicit case being that of 'conversion' leading from simple semantic units (conceived of in Jakobsonian binary terms), over narrative dynamization of these units and to discursivation with iconization, enunciation and the whole set of surface sophistications of the text. Conversion is conceived as the transformation category which adds new, specifying properties to a pre-existing schema – and thus not as variable as the plastic continuous transformations in the two preceding examples.[140] Reference may be made to Petitot's attempt at a catastrophe theoretic modelization of the lower levels of this process, involving plastic transformation possibilities. Yet, the theory contains a less formalized, but analytically strong tool in the so-called 'narrative schema', an idealized textual event process schema based on Propp's more empirical formalization of Russian fairy-tales. Greimas' schema is constructed as a series of presuppositions. A later phase presupposes the earlier phases, not the opposite way around – this implies that any phase of it may deviate from the given norm. It provides, so to speak, a reference tale, and any particular empirical tale may be determined by how it modifies, that is, transforms this arch-fairy-tale. In this case as well, no necessary and sufficient properties may be listed, because any particular property may vanish during the transformation (but not, of course, all of them at the same time). Maybe the fairy-tale in question never produces a hero which is then only imaginarily present, just like in projective geometry. The generalization of Poncelet's principle of continuity thus relativizes the logical ideal of necessary and sufficient conditions, on a purely formal, pre-logical level. The prototypical tale has a hero, of course, but it is possible to transform it into a version with no hero.

This idea is connected to a general fact in the basic use of transformation defining invariants by their insensitivity to (a specific) transformation – this typification creates those entities which, in turn, may be involved in logical calculi. Transformation thus, also in Paris School semiotics refers to a basic geometry preceding logic, even if this is far from always explicitly admitted.[141]

COGNITIVE LINGUISTICS AND SEMANTICS

An actual semiotic current with central transformation concepts is the American cognitive linguistics and semantics (Lakoff, Johnson, Sweetser, Talmy, Turner, Fauconnier, etc., cf. Fauconnier and Turner 2002; Lakoff 1987; Talmy 2000; Turner

1996). Here, I shall only comment upon two related issues, Lakoff-Johnson's metaphor concept and Turner-Fauconnier's blending concept. Lakoff-Johnson's metaphor concept is motivated by the observation of the widespread occurrence of structural, conceptual metaphors in ordinary language: 'Love is a journey' – which then serve as a deep structure with an infinity of surface manifestations: 'Our relationship is not running well', 'We go to therapy in order to add som new fuel to our marriage', 'We cannot find our way together anymore', etc. The idea is that such metaphors map structure from one semantic domain upon another – with the aim of understanding parts of this second domain. This mapping, of course, is a transformation constitutive for the conceptual metaphor in question. Whether the structural similarity between the domains is now constituted by the metaphor or whether, conversely, it has a pre-existing similarity as its condition of possibility is a standing quarrel in metaphor theory, but in both cases the connection between the two fields presupposes a transformation which maps a more general schema (here the gestalt of source-path-goal) from one domain onto the other. Transformation of other bits of structure from other domains onto the same target domain are also possible, of course ('Love is an illness', 'Love is a revelation', etc.), but the decisive kernel remains transformation as a means of understanding. Another category of transformation here goes from the deep structure of the established metaphor and to its manifold of surface manifestations which may be found in a continuum from well-established 'dead' expressions in ordinary language and to more creative, maybe artistic ones. Linguistic usage here plays the same role as designer typography in Hofstadter's case: it investigates the possibilities of established metaphor by further transformation.

Turner's and Fauconnier's blending theory is, in fact, a further generalization of Lakoff-Johnson's metaphor model. They find many cases of coupling between semantic spaces which do not possess the orientation characteristic of metaphor where transformation indicates a semiosis so one domain becomes expression for the other as content. Examples include a philosopher today discussing with Kant and so blending his own arguments with Kant's imagined answers – without any of the dialogue partners being a metaphor of the other. Furthermore, they make explicit the general structure always at stake in transformation by giving it its own mental, 'generic' space, so that any blending has (at least) three typical inputs: those of the two more or less empirical ideas to be blended and that generic structure which facilitates the blend. In this analysis, widespread grammatical phenomena, e.g. compound nouns, are seen as results of semantic blending, characterized negatively by having no compositional explanation (there is no fire in a fire station while there are railways in a railway station – such combinations must hence be seen as blendings).[142] This definition opposed to simple compositionality is equivalent to Hofstadters non-computability claim, also in this case the result becomes a trial-and-error transformation in the lack of general procedure for the mapping of elements onto one another. The relation to Hofstadter's theory is becoming evident, furthermore, in the fact that parts of the two research teams now collaborate – and Hofstadter's work on analogy inferences is a good example of the meeting point of these traditions. Analogy questions are not in general computational; most often they have several possible, not equally brilliant answers. Hofstadter has created a trial-and-error computer program with random components able to solve simple formal analogy questions by running the same questions over and over and thus charting the different possible answers. Analogy questions of ordinary language are, of course, more difficult, because they require context knowledge. Who is Denmark's first lady? PM Anders Fogh Rasmussen's wife? But she does not participate in public life? The queen? But she has a formalized status. The best answer is probably Prince Henrik, the Queen's spouse – even if both of the other two are also possible answers and satisfies different amounts of the requirements of the analogy. The answer to such 'creative' questions thus requires blending – here between an American concept and a Danish context – but the decisive thing in this context is that the investigation of the different answers requires a transformation where an American structure is mapped onto a Danish empirical case which is impossible without certain smaller give-and-take-counter-transformations (in the case of Prince Henrik: he is not a woman) characteristical for blendings. Blendings are thus the formula for a calibrated compromise between different transformations which is why it may not be reduced to compositionality.

HUSSERL AND PEIRCE

After this hasty overview over a series of different and more or less formalized concepts of transformation we shall now go to a more principal level and view them in the context of the more explicit transformation concepts in Husserl and Peirce.

In Husserl, there is a transformation, of course, in his paradigmatic example in the *Ideen* (1980a [1913]): the perceptual synthesis of a series of profiles, shadings, or aspects of an object. These variations of the object are spontaneously synthesized in perception and are understood as aspects of one and the same object because we are able to transform continuously between them. Continuous transformability is thus what grants the objectivity of the object. An analogous procedure Husserl proposes for ideal entities. Already in the Prolegomena of the *Logische Untersuchungen* (1900–01/1975, 1984), the idea of ideal entities is introduced, characterized by the fact that one or more particular properties is substituted by a variable. A decisive phenomenological task is to distinguish between the mode of givenness of individual objects and that of abstract, ideal objects (as is always the case in language). The 6th Investigation investigates 'categorial intuition' as the act which directly presents e.g. grammatical aspects of language and other abstract entities – and Husserl takes care to note the important fact that in such ideal objects the distinction between perception and imagination vanishes, so that imagination is an equally valid way of access to such objects. In the *Erfarhrung und Urteil* (1939, 1985) this is taken further in the theory of *Ideenschau* or *Wesenserschauung* according to which we may grasp essences directly and thus understand an ideal content – by means of the method of eidetic variation.[143] This procedure is, of course, crucial for the determination of the phenomenological prerequisites to logic: in order for logical propositions to appear, involving ideal entities, we must know the way of access to such ideal entities.

We vary the idea by a transformation departing from an example, in principle arbitrarily chosen, incarnating the idea in question. Imagination varies this particular example over a continuum of virtual instantiations. This must presuppose, in order for the search to be exhaustive, that the variation procedure is continuous. Thus, eidetic variation presupposes infinity – the ideal category may be incarnated in a virtual infinity of different extensions. Husserl poses the question of what exactly forces or determines this free variation and prevents it from going anywhere, but he is unable to answer it exactly: there is no given limit (if it was at hand, no variation would be necessary), it is, rather (like in Hofstadter) the very transformative ability to return to the original example which decides how long variation can be drawn. In a certain sense you could say there is nothing further to be said about it if eidetic variation is simply a way for ideal objects to appear, then the investigation has reached its limits (cf. below). Another question refers to whether variation should be actually completed in imagination so that all the extension of possible variants of the idea is in fact covered. In most, if not all, cases this will be impossible, because of the infinity of possible variants (cf. Peirce's doctrine of continuity). If we imagine variation as a continuous change of some parameter in the object, then the temporal synthesis is what grants that all instantiations in the varied segment have been covered – no direct intuition of all those instantiations. We vary, e.g. the size of a triangle, the configuration of the angles, and see that we could in principle take this variation as far in any direction as we might wish. We must, in fact, make the very act of variation into the object of a founded higher-order act which synthesizes some pieces of accomplished variation and judges that it *could* be extrapolated to cover the whole of the idea. Here, of course, is a possible source of error in variation: this higher-order extrapolation may be wrong and overlook important areas of the extension of the idea. A formal equivalent to the *halting* problem of computer science is probably at stake here: it is not possible to devise a general procedure to determine whether a given idea has been searched to a sufficient degree to map all significant variants.

This problem is related to that of what Husserl calls exact versus inexact essences – which may be distinguished according to whether variation may predict all single concrete instantiations of the idea: in the concept of the triangle, variation is synthesized and it is realized that an extrapolated variation will be able to produce all possible triangles with all possible combinations of side and angle sizes. In inexact essences – e.g. empirical universals – this is not possible, which is why Husserl concludes that these remain 'vague morphologies' inaccessible to axiomatic treatment (*Ideen* §§71–75). We know, however (Gödel's incompleteness theorem, of which the *halting* problem forms a computational version) that axiomatic systems exist where not all concrete variations (theorems) may be formally predicted. To that extent, the distinction between exact and inexact essences is more blurred than Husserl realized. But the positive correlate to this incompleteness insight is that also essences which are not completely formally decidable permit more or less comprehensive formalization (e.g. already natural numbers). As the many different uses of the concept of transformations in semiotics also seem to hint at, it is thus not impossible to specify different formal properties in a variation mapping inexact essences, and even if there is a central point in the fact that they may not be axiomatized and rendered in necessary and sufficient properties, then a huge open field remains regarding the mathematical formalizability of these ideal objects (both a priori, tied to the material ontology of the essence in question, and empirically).[144]

The concept of eidetic variation has from time to time been wrongly taken as a strange, mystical ability – but it is important to maintain that it is a completely ordinary everyday process as a thought experiment isolating a type by transformation. Eidetic variation is so broad a concept that it probably founds the more specific semiotic transformation types we have here discussed. Even if ideal objects may be accessed through variation it is not their only mode of givenness: representation by a bound variable (an *x*, an empty slot, a place to be filled in, a variable property), be it explicit or not, is another representation of ideal objects – from literary works to equations. There is no real understanding without ideal types which are for that reason widespread all over semiotics (the typical sign as such, for one, is ideal).

As is evident, eidetic variation is closely connected to a non-inductive abstraction theory. This leads us to what is, in fact, Peirce's version of eidetic variation, also built upon a non-empirical theory of abstraction. Abstraction is, in Peirce, several different things (and just like in Husserl distinct from the issue of induction.).[145] First, it involves 'prescission' which is an act of focusing, which disregards certain irrelevant properties in order to focus instead upon other, relevant properties. In this procedure, the removal of properties corresponds to the introduction of a variable as the precondition of the isolation of a predicate (e.g. the isolation of the property 'round' from the other properties of an object). Another procedure is 'hypostatic abstraction' as the procedure which makes a new subject out of a predicate in order to facilitate further investigation (investigating, e.g. 'roundness' as such). These two transformations are the prerequisites for the construction of a diagram (in this example: a circle) making possible the schematization of the content of a concept and its ideal grasping (Peirce calls this the observation of universal propositions). By the variation of this diagram different transformations may investigate the extension of that idea, its limits, its relation to cognate diagrams (the point; ellipses and other conic sections; polygons), the impossibility of squaring it, circumscription by polygons, etc. – all results which appear with the necessity of ideality. The lawlike aspects of empirical investigation thus involve the incarnation of diagrams in the matter in question – thus Peirce's idea of the role of diagrams in knowledge thus provides his equivalent to Husserl's concept of eidetic variation. It even adds important details of the variation procedure, first its phases of focusing, hypostatization, and variation, second its distinction of different classes of variation. A decisive distinction to Peirce already mentioned is that between 'corollarial' and 'theorematic' diagram experiment. The former is directly read off the diagram while the latter requires the introduction of new entities in the diagram (cf. the helping lines and similar constructions in geometry). The latter requires an abductive 'jump' in variation[146] and thus makes evident why variation is not always an intuitively easy transformation (cf. the existence of unsolved and undecidable questions). As in Husserl where variation may distinguish ideas in still higher generality, leading to the issues of formal and material ontologies, transformation is also in Peirce recursive: a new variation may take the former as its subject in a new higher-order diagram.

Husserl's and Peirce's very general concepts of transformation, eidetic variation and diagrammatic experiment, respectively, closely connected to the mode of existence of ideal objects in general, make evident the very basic status of transformation. It can be argued that a series of ontological issues which are often taken to be primitives in semiotics (and elsewhere) are tied to transformation. Thus, e.g. the distinction between static and processual states-of-affairs which have given rise to so much vitalist discussion (e.g. in post-structuralism). Transformation precedes both 'static' and 'dynamic' issues – they refer to two different interpretations of a transformation as being a relation between two entities and as being something taking place in time – so to speak equivalent to the question of *Geltung* and *Genesis*.[147] Transformation does not choose any of the two sides but makes possible investigations of valid, a priori relations between concepts on the one hand and genetic investigations into the empirical change of objects on the other hand. Similar relations probably hold in the highly ideologized issue of identity/similarity/difference. An assumption of identity may probably be tied to any transformation – the invariance it allows for may be interpreted as the identity of an abstract object through change – an identity being so much more general, the larger the amount of varied properties are, and the less the core kept invariant. To this extent this 'semantical' notion of ideal identity (different from the numerical identity of empirical existence) is relative to the set of transformations used. This explains the trivial fact that any object is in some sense similar to any other object[148] – at the same time as explaining why this is not valid as a criticism of similarity as such: similarity is not arbitrary but relevant to the transformation chosen. Thus, transformation does not chose sides between harmonizing *Identitätsphilosophie* on the one hand and radicalizing philosophy of difference on the other: it is a means of description preceding both.[149]

This chapter has taken us from different specific uses of transformation concepts in semiotics and to their generalization in Husserl's and Peirce's theories for the ontology and epistemology of ideal objects and their transformations to which we shall return in more detail in the next chapter. We may here sum up the different pragmatical tasks for transformation: the emphasis may be placed on invariance (identity), on variance (the process), on the comparison between the two ends of transformation (similarity/difference), the comparison between different transformations of the same object, on repeated variations back and forth between two or more transformands (judgment/blending), on the transferral of further, more or less untransformed matter (metaphor), on a double grasping of the resulting object as the output of several different transformations.

As to semiotics especially, the following tasks may be listed:

- abstraction (cf. Peirce's prescission and hypostatic abstraction, respectively)

- categorization (categorical perception as the transformation of a continuum to a discrete system)
- to grant identity (of types, from phonemes and morphemes up to more comprehensive signifying structures)
  a) to understand a token as instantiation of a type
  b) to achieve overview over a type
  c) to constitute a type
- to synthesize a manifold
  a) in perception
  b) in categorical intuition
- to detect similarity (by comparative synthesis of the transformands)
- to map concepts (cf. Peirce: concepts as transformative conditionals, the meaning of a concept being coextensive to the transformative effects the object of the concept may be conceived to possess)
- to generate a variation of subtypes in a hierarchy of ideal entities (correlative to subsumption under a type), and connected to this:
- to constitute regional (material) ontologies
- to constitute and describe iconic signs as well as the iconical component in higher sign types (as correlation between types)
- to grasp the aspect of an object as the arche-form of the sign (selected by transformation) – cf. also the proposition ('this aspect is an aspect of this object /these objects')
- to reasoning as a transformation guided by the invariance of truth (and, more unfolded, by the invariance of possibility, truth, probability, corresponding to ab-, de-, and induction)
- to understand something in terms of something else (cf. Turner's 'literary mind': allegory as a basic procedure), and correlatively:
  a) analysis (of texts)
  b) integration of concepts (blending, analogy inference)
  c) recursivity (the transformation of transformations)
- answering questions/solving riddles (with the trial-and-error transformation involved) – cf. Hintikka's game-theoretical semantics

Many of the theories touched upon in this chapter are not traditionally classified as semiotics (mathematical, biological, philosophical theories). Why then keep that notion as a headline for the whole field of thought and meaning made possible by transformation processes? This issue comprises both empirical, natural phenomena (d'Arcy Thompson) and ontological and epistemological basic issues. The term semiotics only has a relevance for this vast field if it may be understood as based on meaning. This, in turn, is only meaningful if we take 'meaning' in an objective sense (cf. biosemiotics, Chaps. 9–12) comprising teleological processes in the empirical world without requiring any observing subject in anthropomorphous sense – and, if it comprises access types to the ontological zoo of different ideal objects on the other hand. Human thought and language are, of course, a privileged access to these ideal objects which must not lead to the idea that these objects are restricted to or created by the human mind, a fallacy which, depending on regional ontology chosen, will lead into biologism, historicism, psychologism, subjective idealism, or other reductive –isms – all of them springing from a genetic fallacy assuming that ideal objects and the transformations defining them should pertain to a specific and delimited ontological field. Transformative semiotics, in this use of the word, will cover much more than usually assumed – what is won, on the other hand, is the understanding of transformation as the basic process of semiotic intelligence: only a reifying forgetting of transformation (probably motivated in the efficiency and invisibility of most of the basic procedures of our cognitive apparatus) makes us overlook transformation being pervasive in our everyday perception, language, and reasoning.