Abductive Reasoning as a Way of Worldmaking

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The Gods have certainty, whereas to us as men conjecture [only is possible]..”
Alcmaion von Kroton (Diels /Kranz, Vol. I,p. 214)
"...the true method of philosophical construction is to frame a scheme of ideas ,
the best that one can, and unflinchingly to explore the interpretation of experience
in terms of that scheme." (Alfred North Whitehead 1978, p.xiv)
"...man's truth is never absolute because the basis of fact is hypothesis."
(Ch. S. Peirce, Writings vol. I, p. 7.)

Abstract
The author deals with the operational core of logic, i.e. its diverse procedures of inference, in order to show that logically false inferences may in fact be right because - in contrast to logical rationality - they actually enlarge our knowledge of the world. This does not only mean that logically true inferences say nothing about the world, but also that all our inferences are invented hypotheses the adequacy of which cannot be proved within logic but only pragmatically. In conclusion the author demonstrates, through the relationship between rule-following and rationality, that it is most irrational to want to exclude the irrational: it may, at times, be most rational to think and infer irrationally. Focussing on the operational aspects of knowing as inferring does away with the hiatus between logic and life, cognition and the world (reality) - or whatever other dualism one wants to invoke -: knowing means inferring, inferring means rule-governed interpreting, interpreting is a constructive, synthetic act, and a construction that proves adequate (viable) in the "world of experience", in life, in the praxis of living, is, to the constructivist mind, knowledge. It is the practice of living which provides the orienting standards for constructivist thinking and its judgments of viability. The question of truth is replaced by the question of viability, and viability depends on the (right) kind of experiential fit.

1. Logic, the world, and human inference

The above motto by Alcmaion characterizes human knowledge as limited and specifies its range as the domain of "the inferred" („conjecture“).[i] Knowing is thus conceived of as an inferential, active, process on the part of the knowing subject, the subject manufacturing his/her knowledge by means of drawing conclusions or deriving statements. If, however, inferring can be understood to be the rule-governed progression from A to B, from the One to the Other, then all the processes classified as processes of understanding necessarily involve rule-bound inference.[ii]

Now traditional logic has been dealing with such rules of inference since ancient times and thus with the operational basis for the manufacturing of knowledge, i.e. of true statements. "Laws" of logic must govern the order according to which humans think, speak and reach conclusions which are judged to be rational. This understanding of rationality is consequently tied to logic and its "rules of thought", i.e. to logical rules of inference and the categories true/false. Since the time of Aristotle logicians have been trying to separate the valid forms of syllogistic inference from the invalid ones in order to pave for human reason the rational, the royal, road leading to true knowledge. The structures of logic apparently are the objective bounds of what is thinkable (logos). In its history, the "objectivity" of logic has been justified by, amongst other things, the belief that the "laws" of logic mirrored reality (ontology), that they reflected structures of reality by virtue of their being principles of the mind (of thought, of language). Such a realist conception of logic considers it to represent structures of a reality or super-reality independent of itself.

A representationist conception of logic cannot be consistently upheld, however. Logic does not mirror an independently existing order, logic, too, and all its "laws", are much rather "posited" (thesei), i.e. manufactured by a community in communication, and not discovered. The "laws of logic" may be understood as the discursive rules of a game that cannot be justified "retro-gressively" by having recourse to some real or fictitious ontology, but only "pro-gressively", pragmatically, i.e. by their fitting into the discursive and material environment constraining the game (von Wright 66, Fischer 1999b).[iii]

In this article I want to deal with the operational core of logic, i.e. its diverse procedures of inference, in order to show that logically *false* inferences may in fact be *right* because - in contrast to logical rationality - they actually enlarge our knowledge of the world. This does not only mean that logically true inferences say nothing about the world, but also that all our - logical or para-logical - inferences are invented hypotheses the adequacy of which cannot be proved within logic but only pragmatically, i.e. by showing that they improve both our orientation in the world and the way we control or manage our lives. In conclusion I should like to demonstrate, through the relationship between rule-following and rationality, that it is most irrational to want to exclude the irrational: it may, at times, be most rational to think and infer irrationally.
Bringing the operational aspects of the processes of knowing into focus in this way, we can show how conceptual systems come about, ordered sets of concepts/ideas that are not given, or found "pre-existent", as traditional ontology assumed (to *on*, Greek for "Being"), but must be created by the human observer. It thus becomes evident, furthermore, that radical constructivism has no need for the idea of 'representation' (Latin *repraesentatio*) and an ontology in the classical sense. Radical constructivism tries to avoid ontological statements about the "real" nature of the world and leaves behind the idealist notion of an immanent essence or an immanent nature of the world which is alleged to be amenable to human knowing.
Radical constructivism, as a psychology of knowing, first and foremost discards the loaded concept of representation and specifies knowing as a predominantly self-referential process: human subjects possess no knowledge other than the knowledge they have themselves created through operations within their own cognitive systems. Constructivist thinking considers abductive inference to be the only knowledge-generating mechanism. I shall, therefore, analyse the logical form/structure of abductive reasoning and demonstrate that it is the constructive modus operandi of the process of knowing which may be seen at work not only in all the processes of understanding but also in the classical nomological-deductive schema of scientific explanation.

Focussing on the operational aspects of knowing as inferring does away with the hiatus between logic and life, theory and praxis,

cognition and the world (reality) - or whatever other dualism one wants to invoke -: knowing means inferring, inferring means rule-governed interpreting, interpreting is a constructive, synthetic act, and a construction that proves adequate (viable) in the "world of experience" (German: "Wirklichkeit"), in life, in the praxis of living, is, to the constructivist mind, knowledge. It is the practice of living which provides the orienting standards for constructivist thinking and its judgments of viability. The question of truth is replaced by the question of viability, and viability depends on the (right) kind of experiential fit.
My points of departure are as follows:
All forms of knowing, thinking and perceiving are tied to, or mediated by, signs (Peirce, Wittgenstein).[iv] "Raw data", "givens", "reality", or whatever name the dualist gives to the independent Other supposedly confronting the cognizing subject, are cognitively inaccessible. Furthermore, all such sign processes are inferential processes, i.e. thinking, communicating, and even perceiving itself, may be understood as processes of interpretation, as inferential processes that encode signs and thus assign meanings.
The most important form taken by cognitive and interpretative processes is abduction: "worlds" ("experiential realities" = "wirklichkeiten") are manufactured by means of abductive procedures. Nelson Goodman never tired of affirming that we are worldmakers, that we create new worlds out of old.

2. Inferential procedures: deduction and induction

Charles Sanders Peirce (1839-1914), the founder of pragmatism, spent four decades on the investigation of induction and deduction, models of thinking well established in logic and the philosophy of science, and supplemented them by an inferential procedure which he called abduction.
In the context of this article I can do no more than develop an extremely reduced version of this subtle theory which Peirce worked on for over thirty years.
He distinguished three kinds of inference: deduction, induction, and abduction. The abductive form was first called hypothetical, then abductive, then retroductive, and only at a later stage abductive consistently. [v]

Aristotle dealt with deduction and induction but did not analyse abduction in detail; abduction, therefore, remained absent from the history of logic until it was "re-discovered" by Peirce. In a semiotic theory of cognition abduction plays a decisive role because only by abduction can we add to our knowledge of the world. I shall, therefore, concentrate on this form of inference.
Peirce introduces the new kind of inference as "reasoning a posteriori"[vi], thus setting it apart from deduction a priori, and he replaces the three classical terms, major premise, minor premise, and conclusion, by his own terms: rule, case, and result. In this way, the sequential order in which the premisses and the conclusion are known may be taken into account. Thus each of the three statements of the classic syllogism could in principle take any of the three positions, whether they are rule, case or conclusion. The minor premise (the second premise of the classic syllogism), for example, may become the inferred conclusion, as is the case in abduction.The major premise which contains the predicate may naturally also be formulated as a rule (law): All humans are mortal. If X is human, X is mortal.
Let me present here the most famous of all syllogisms, the Modus Barbara, the deductive model of inference of the first figure[vii], the best-known instance of which has to do with the immortal Socrates:

Major Premise(rule): All humans are mortal (MaP).
Minor Premise (case): Socrates is human (SaM).
Conclusion (result): Socrates is mortal (SaP).

The categorical syllogism relates three concepts, S (subject), P (predicate), and M (middle), in three statements (major premise, minor premise, conclusion) in order to examine their validity. I have added these terms to the statements and included in brackets the abbreviations indicating the characteristic position of the concepts in the first figure (MP, SM, SP).
In Peirce's view, the goal of all inferential thinking is to discover something we do not know and thus enlarge our knowledge by considering something we do know.[viii]

In view of what has been said, the inferential procedures presented here are of different quality with regard to the way in which they increase our knowledge. In Peirce's terminology, the three forms of inference are the following:

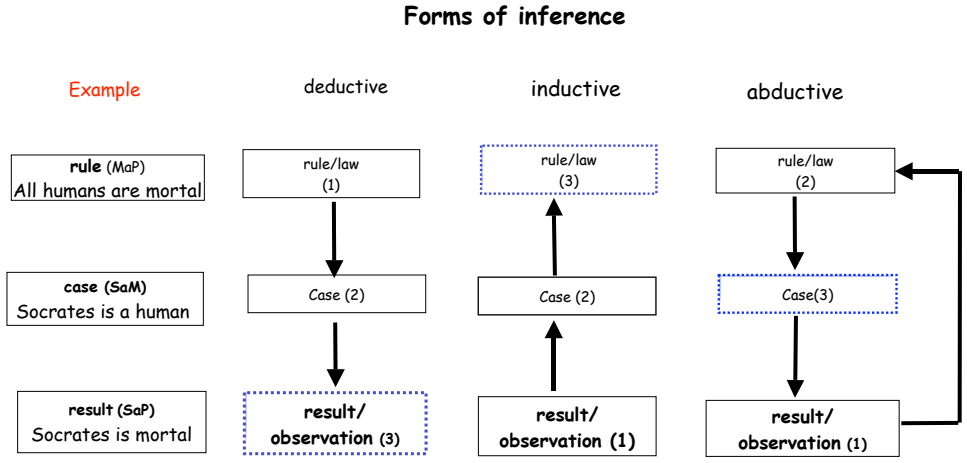


Figure I: Forms of Inferences
Boxes with continuous lines contain premisses/hypotheses that are presupposed as given/true.
Boxes with dotted lines contain hypotheses that are inferred.

In logic as well as in the philosophy of science a valid deduction is considered to be truth-conserving; if the premisses are true, the conclusion must be true, too. The price to be paid for this necessary truth, however, is that the information content of the conclusion is already implicitly contained in the premisses. The "mortality of Socrates", the conclusion supplied by Modus Barbara, is nothing new, it was completely contained in the premisses. Deduction, therefore, is not synthetic (content-increasing), does not lead to new knowledge. It is analytically true (redundant) and has, therefore, been considered to be merely an "explanatory statement" in the more recent discussion. Deductive thinking proceeds from the general (the rule), through the subsumption of the singular case under the rule, to the assertion of the particular (the result), as the arrows in figure 1 indicate.

Peirce developed his theory of induction over several decades, so I can only present a brief summary of its essentials.[ix] In the case of induction the premisses (the initial basis) are observational statements, and an inferred conclusion (e.g. a hypothetical rule: All M are P) is considered to be content-increasing but not truth-conserving because the inference is only a hypothesis that cannot be proved with ultimate certainty.[x] Induction - the converse of deduction - progresses from the particular to the general. Therefore the arrows point "from the bottom to the top".

For a long time, Peirce classified induction as a synthetic inference until he had an insight of the greatest relevance to the philosophy of science, namely, that a valid induction already presupposes as a hypothesis the law or the general rule (M is P) which it is supposed to infer, in the first place.

For Peirce inductive inferences, must satisfy two conditions in order to be valid: the sample must be a random selection from the underlying totality, and the specific characteristic that is to be examined by means of the sample must have been defined before the sample is drawn. The significance of this requirement, called "pre-designation" by Peirce, for the definition of inductive inference is

that the predicate P must already be known before the sample (S', S", S"') is selected from the totality (M). „ If, however, the property to be examined must be defined before the sample is selected, this is only possible on the basis of a conjecture that the property exists in the corresponding totality before the inductive inference is made. How else could the property be known in advance of sample selection? Valid induction, therefore, already presupposes as a hypothesis the conclusion that is to be inferred. More precisely, inductive reasoning is based on a given hypothesis (M is P) and then, by means of samples (S', s"), seeks to establish the relative frequency (p) of the property (P) in the totality (M) with regard to that hypothesis...“ (Riemer, op. cit., p.25f.) The condition that the property to be examined must be pre-designated in advance of sample selection makes Peirce conclude explicity that induction cannot lead to new discoveries.)

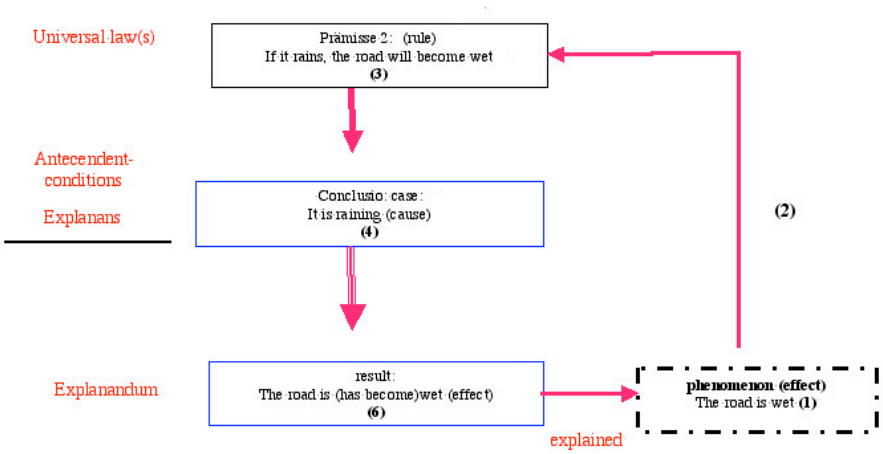
This could mean that the scientist is bound to know already (implicitly) what he does not, in fact, know that he knows.
As it is logically excluded that there can be knowledge before knowing, the cognizing subjects must invent hypotheses on their own before any experience or experimentation can take place. Peirce's logical analysis shows, on the one hand, that induction does not belong among the synthetic forms of inference that, in one way or another, may enlarge our knowledge of the world. On the other hand - and this is of the greatest relevance to the logical foundations of radical constructivism - , any kind of induction is dependent upon hypotheses which must have been constructed beforehand by cognizing subjects. And this process of construction is abductive, as far as its logical form is concerned. If, however, neither induction nor deduction enlarge our knowledge of the world, then abduction as the only knowledge-generating mechanism must needs become the central focus of epistemological discussion. So I shall now discuss in detail what the logical form of abduction is like and in what respects it is interesting and relevant for radical constructivism.

3. Abductive inference

The abductive mode of inference involves two steps. In a first step a "phenomenon" to be explained or understood is presented (1), in Peirce's

terminology, a "result", which is the derived conclusion in the classical schema; then a second step introduces an available or newly constructed hypothesis (rule/law) (2) by means of which the case (3) is abduced.
Peirce has examined these three modes of inference in great detail and shown convincingly that all three operate together in our thinking in different ways. Here I shall concentrate on abduction only.
What is the function of abductive inference? For Peirce it is " the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea; for induction does nothing but determine a value, and deduction merely evolves the necessary consequences of a pure hypothesis. Deduction proves that something must be; induction shows that something actually is operative; abduction merely suggests that something may be“ (CP 5.171, cf 1991a, p.333). Abduction may thus be conceived of as a principle that allows us to reconstruct how conceptual order is achieved through the imposition of a hypothesis (in the form of a minimal theory, an idea, a rule or a law-like hypothesis) - which inaugurates constructivist thinking. Here I can only hint at the great variability of this schema; it enables us to bridge the traditional gap between the arts and the sciences because it can be used as a model both of explanation and of understanding.
Presented as an inverted modus ponens - as in Peirce's writings - the abductive schema looks like this:

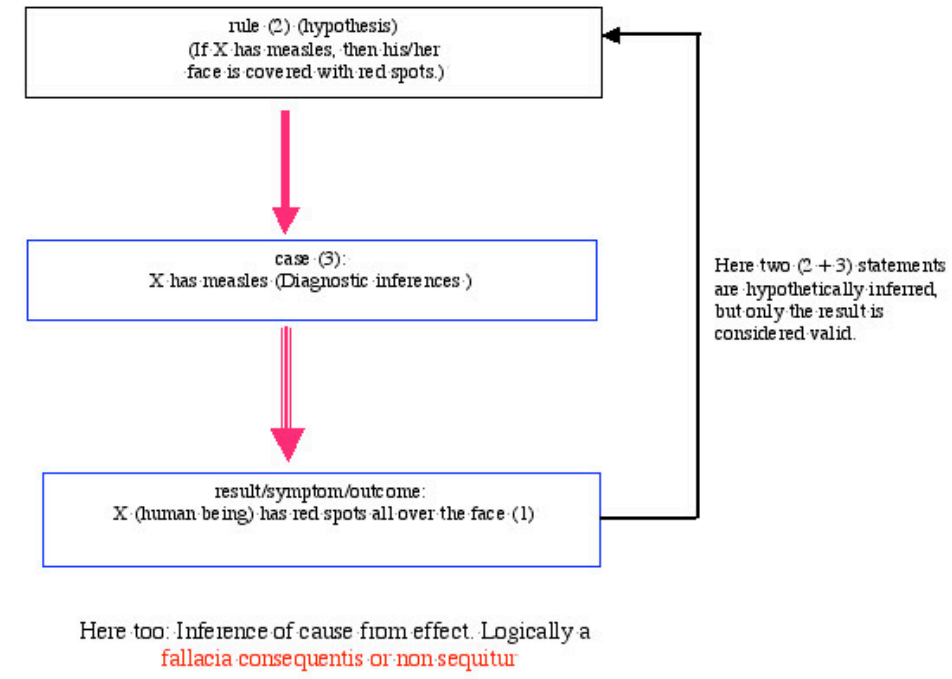
Figure 2. Abductive Reasoning as an Inverted Modus Ponens:
from Effects to Causes (causal explanations)



This schema becomes a (nomologically-deductive) explanatory principle if the first premise (the result) contains an unexplained surprising fact (perception, observation) - for Peirce the beginning of all scientific querying - which is then explained causally as the effect of a cause. In this context, Peirce also speaks of "reasoning ... from consequent to antecedent" (CP 6.469, 1.74), of reasoning from effects to causes, - a fallacy in (traditional) logic (a fallacia consequentis). The causal formulation of the explanation of the phenomenon that the road is wet would run as follows: The road is wet because it is raining (because it has rained). The rain is the cause inferred from the effect (the consequent).[xi] Abduction, i.e. inferring causes from effects, represents an explanatory principle which, though logically invalid, may still be confirmed inductively.[xii]
The (potential) confirmation of such hypotheses (logical inferences or theories) says nothing about reality (ontology) in the sense of a representation or mapping but only that the hypotheses are functioning. Therefore, the structures of our logic(s) or our theories do not mirror the structures of things nor are they derived (deduced) from them. With the primary act of the formulation of such a hypothesis a paradigm, a rule, a method of measurement is provisionally laid down by means of which we then "measure" or "compare" what we conceive of as "nature". Only in a second act arise the notions of "correct/incorrect", fitting/non-fitting, rule-conforming/rule-breaking etc. [xiii] The actual constructive act consist in the apriori specification of a "measuring method" by the cognizing subject (the scientific community) because the world cannot determine for us directly what kind of measuring method or paradigm we must use. And just as the measuring method must be specified before measuring can take place, so induction must be directed/governed/controlled by a hypothesis that has been constructed abductively beforehand. The world, or nature, thus functions as a selection mechanism, as a constraint, which determines whether our hypotheses fit or fail. In the latter case the scientific community is forced to change the theories, paradigms or conceptual systems in such ways as will allow the derivation of viable

hypotheses that enlarge our knowledge of the world in the constructivist sense. Viable hypotheses, therefore, do not admit of positive statements about how the world really is but only negative ones to the effect that other hypotheses do not work. We can, on the other hand, also draw the conclusion that, for a reality different from ours, we would need other "standards", other systems of categories etc. to be able to orientate ourselves in it because the ones we have would not work.
If an abductive inference establishes itself in the scientific community as a new paradigm (a new explanation of a certain phenomenon, like Kepler's hypothesis of the elliptical orbit of the planet Mars), then the logic[xiv] of the corresponding conceptual system has changed.

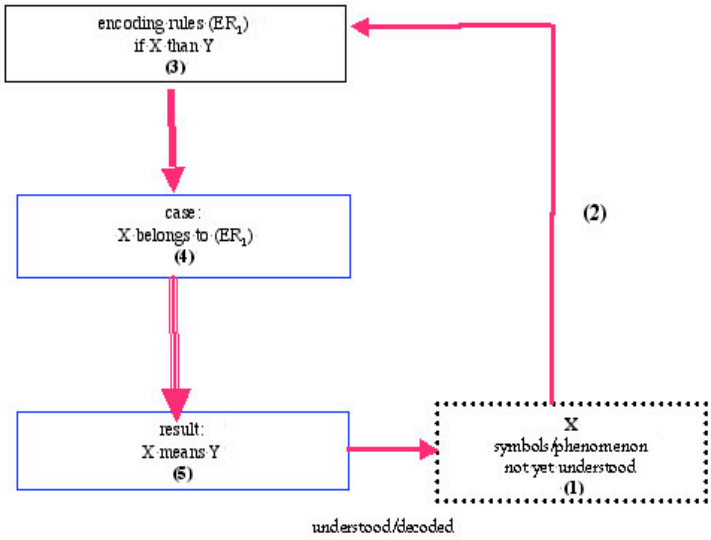
Figure 3. Diagnostic inferences are abductive, too.
An example of a medical diagnosis.



Here too: Inference of cause from effect. Logically a fallacia consequentis or non sequitur

Every diagnostic statement by a medical expert functions as an abductive inference.

Figure 4. The construction of meaning in a system of signs
Abductive inference as semiotic exegesis/interpretation



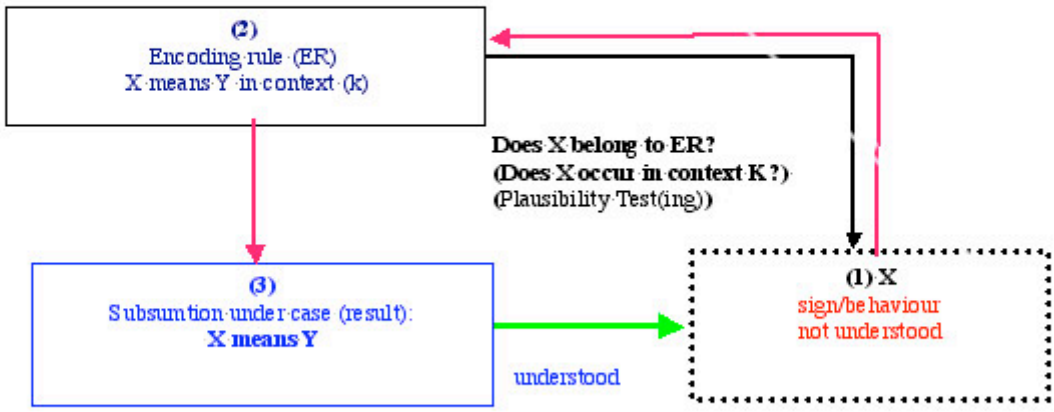
As a process of finding a premiss (hypothesis), abduction is the basis of all hermeneutical procedures, the inference from phenomena (behaviours, actions) to motives/intentions/puposes.

If we replace the surprising fact by the incomprehensible behaviour of a person, then an abductive inference may help us to construct an intentionalist explanation through motives (reasons) that makes the behaviour intelligible. All intentionalist or functionalist explanations in psychotherapy thus become interpretable as hypothetical constructions with abduction as their modus operandi.

(1) Observation: Person A shows behaviour V in context K, utters x, etc.
(2) Hypothetical rule: A behaviour x in context K has the meaning/function (f).
(3) Case/conclusion: A's behaviour V has the meaning (f) (is motivated by f).

If we consider the mechanism on the semiotic plane, a sign is introduced as an unexplained result to which, by way of the construction of an encoding rule, or the application of a familiar encoding rule, meaning is or can be assigned (contexts, frames, etc. being of significance, too).[xv]
Abduction, as a cognitive operation, creates the framework which makes it possible to attribute a singular meaning to signs. The interpretation of signs - as the schema shows - is always abductive, or in other words: the fundamental constructive principle of all semiotic interpretation is the finding or inventing of a hypothesis (abduction), i.e. the act of semiotic understanding on the part of a hearer can
consist only in the attribution of meaning through a - his/her - frame of reference (encoding rule).[xvi] Therefore, abductive inference is the basic principle of all hermeneutical procedures.

Figure 5. The construction of meaning in a semiotic system /system of signs
Abductive inference as the interpretation of signs, or as an intentionalist explanation



Peirce writes about abduction, that „… It´s only justification is that, if we are ever to understand things at all, it must be in that way.“ (Peirce 5.145)
How do we proceed from seeing to knowing, from the affection of our senses to the description of our perception in language? Here, too, abductive procedures are at work: as soon as I describe my perception linguistically, I interpret non-

verbal signs abductively and transform them into language in a rule-governed way. Against the background of abduction theory it is trivial that perceptual judgments are constructive in themselves, are already interpretations. [xvii] All perception is, therefore, in principle construction.
Carrying out inferences, therefore, does not always involve conscious reflections before we reach our conclusions; frequently these inferential processes take place below our level of awareness, as Peirce himself repeatedly states and defends (Peirce 1975, p. 107f.).
Deductive inferences ("inference a priori") do not yield anything new, only abductive reasoning leads to really new paradigms and can, therefore, be considered as knowledge-increasing.[xviii]
Applying the theory of abduction to the brain brings out the precise logic of Maturana's theory of autopoiesis. For the observer, the brain thus becomes comprehensible as an autonomous organ of abduction which, under the control of internal "rules" (cognitive maps, memory) which are not fixed/determined by the external world, neuronally encodes the stimuli (perturbations) impinging upon the sensory receptors (this would quite literally be "in-formare") and so generates information from those stimuli.

Abductive inferences are of the kind of hypotheses, they are logically invalid and must, therefore, be corroborated deductively (within conceptual systems and theoretical frameworks) as well as inductively, i.e. pragmatically, by experience.[xix] Knowledge becomes intelligible by way of its abductive incorporation into a coding system (semiotic system/system of signs) the logic of which forms the frame within which the facts (phenomena) acquire meaning by virtue of having become signs. As synthetic inferences are content-increasing only if they go beyond the information contained in the premisses, and as the conclusion predicates of the subject something not available in the premisses, our thinking cannot and must not remain merely deductive if we want to enlarge our knowledge.
If we take Peirce's theory seriously, then the hiatus between theory (logic, thought) and praxis (living, being) can only be bridged by means of abductive modes of inference; both deductive and inductive reasoning procedures prove to be incapable of creating new information and can, therefore, not lead to new knowledge. It is the central insight of the theory of abduction that there is no

induction without a pre-existent hypothesis which has been inferred or constructed abductively.[xx] Thus the constructivist hypothesis is confirmed that knowing is a path emerging from walking, and that we can only enlarge our knowledge of the world by inventing hypotheses that prove to be viable in the process of searching for paths.
In this view all the changes in our thinking, all our new ideas and all additional knowledge, are the results of violations of established "laws of thought", taxonomies or logics, by way of para-logical thinking.
Such inferences comprise judgments which themselves rest upon hypotheses (conjectures, beliefs, minimal theories) that cannot have been determined by reality. In other words, if to know a phenomenon (an event or thing) means to be able to explain it, then every kind of explanation is "only" inferred, only the result of an inferential act that itself rests upon a hypothetical basis and is without absolute support.[xxi]
Inferences - and this also holds for abductive inference to the case, the minor premise - are, for Peirce, "constructions" of representations of reality, not its images,[xxii] so that the truth of an inference can only be proved pragmatically by way of further inferences, as Peirce would say. This is the kind of reasoning referred to as "viability" by Ernst von Glasersfeld.[xxiii]
The seeds of all kinds of ways of worldmaking are contained in abductive inference.In semiotic terms, an abduction functions as the incorporation of a sign into a coding system (minimal theories, hypotheses) the logic of which forms the frame within which the phenomena that have become signs acquire meaning.
Abductive inference, in comparison with logical rationality, is para-logical, irrational. Still, to me this mode of inference seems to be the most relevant form of thinking at all. The reflection of abductive inference thus leads us to a new understanding of rationality.[xxiv]

4. Rationality and rule-following

Just as measuring requires a measuring standard,[1xxv] so our understanding of rationality presupposes that everybody draws inferences in the same way, i.e. follows the same rules.
With recourse to Wittgenstein's late philosophy of grammar (logic) which I have dealt with extensively elsewhere (Fischer 1987), I should like to

summarize the relationship between rationality and rule-following in the following way: Language exists only where rules are at work, and the same holds for what we call thinking. Wittgenstein's analyses demonstrate that local rule systems like language games are a conditio sine qua non of rationality. What is described as reasonable or rational appears to be the consequence of rules or of processes organised in a rule-like way, and not the reverse (Hayek 1980; Keller 1990; Fischer 1999a, b). Rule-following is a kind of praxis that can only be accounted for pro-gressively, in a feedforward loop, i.e. pragmatically, because any retro-gressive account becomes caught in a vicious circle. Rationality, therefore, is not the foundation of rule systems; we follow the rules blindly - as Wittgenstein says (1953, Philos Investigations § 219) - as soon as we have learned to talk and think.

Rationality is conceivable only on the basis of rule-following. And so the possibility emerges to give up a concept of rationality that is dogmatically tied to logic, and to discover rationality in the irrational.

Making an inference in a way deviating from logic, as is the case with abduction, therefore counts as "fallacious" from the logician's point of view. If, however, the hypothesis is correct that rule-following is the foundation of all rational thought, then the question poses itself whether para-logical inference follows rules which are different from the established ones. If this is accepted, para-logical thinking can be made intelligible in principle. In other words, and for me this is the decisive point, there is a transition from fallacious thinking to a different kind of thinking. And it is precisely this sort of transition that cannot be managed with and in traditional logic because it consists essentially in its violation. From this point of view, abductive inferences do indeed violate logical laws, but they may be interpreted as creative changes of the semantic content of concepts or conceptual systems (language games), - as is, by the way, the case with all "paradigm changes". There is no absolute standard for the rationality of thought and action, but only a relational one. By means of creative abductions - where a new "major premise" (hypothesis: M is P) is invented - new and different standards are constructed. Standards - like the laws of logic - are not true or false in themselves but only more or less useful in the realisation of particular interests or goals. Here one must distinguish between logical correctness and what is right in the sense of a standard borne out by ordinary practical living, - this is the meaning of fit. It is, therefore, ultimately pragmatic - and not logical - criteria that determine whether para-logical thinking permits

viable action capable of inductive corroboration. Pure logic is inadequate to judge the rationality or irrationality of an utterance or an action because para-logical (abductive) inferences or hypotheses may, in fact, be rational (i.e. correct). Their rationality, however, is different from the rationality chained to Aristotelian logic.
Peirce, consequently, assigns rationality to para-logical abduction if it serves to control human actions: " An Abduction is a method of forming a general prediction without any positive assurance hat it will succeed either in the special case or usually, ist justification being that it is the only possible hope of regulating our future conduct *rationally*, and that Induction from past expereince gives us strong encouragement to hope that it will be successful in the future." (CP 2.270; my emphasis)

To the extent that such abductive inferences open up new knowledge and/or change the semantics of a conceptual system, they prove to invent or construct relations, transitions and connections which did not (have to) exist before or could not be seen or perceived at all.
If abductively constructed hypotheses are corroborated inductively then the experience-prior rules (logic) of a conceptual system are transformed or adjusted, - as is the case with all "scientific revolutions". Such creative abductions must be seen as adjustments of theories, logics, standards and norms of thought, in fact, of our total conceptual universe (world picture), they change our mental map(s) more or less fundamentally.

NOTES

[i] The second part of the quoted fragment by Alcmaion runs: "Man is distinguished from the other creatures in that he alone comprehends, whereas the others, though they perceive, do not comprehend." (loc. cit. p. 214). Here already the important distinction is drawn between perceiving and knowing (i.e. com-prehending by means of concepts).
[ii] "...every judgment results from inference... ... Every exercise of the mind consists in inference" (Peirce CP 5.328). Innumerable other relevant passages might be quoted here. In reply to the question what he understood by a sign Peirce wrote: "... all inferring or reasoning is th interpretation of some sort of sign." S.191, SS1, MS 404). That all cognitive processes were of inferential character was the standard position in psychology around the turn of the century. William James, for instance, in his classic Principles of Psychology (first published 1890, vol.2, p. 111ff.), criticizes the view held by Schopenhauer, Wundt, Helmholtz and others, that perception itself was unconscious inference-making.

[iii] See Fischer 1999a and 1999b for my arguments against this conception of logic, taking up ideas of the later Wittgenstein and of G.H. von Wright.
[iv] See, for example, Peirce CP 5.251: "The only thought, then, which can possibly be cognized is thought in signs. But thought which cannot be cognized does not exist. All thought, therefore, must necessarily be in signs."
[v] Peirce's classic beans example keeps emerging again and again in his work, its first premise, though, involving three concepts:
All the beans in the bag were black. (Rule)
These beans are from this bag. (Case)
These beans are black. (Result)
(CP 2.6623, Peirce 1991, p.223 or W I, p.429ff.) Peirce himself speaks of "totally irrational" inferences in connection with "paralogisms" (W I, p.437. Lowell Lecture 1866).
[vi] See Richter (1995), p. 15. Richter's book is an extensive history of the concept of abduction, well documented by original textual evidence. Peirce, too, in the traditional anti-psychologistic manner, keeps pointing out that logic as the study of thought had nothing to do with psychology, although, with abduction, he himself finally tore down the walls between logic and psychology.
[vii] Aristotle's doctrine of syllogistic reasoning comprises three figures ("schemas") to which later a fourth figure was added. They are distinguished by the position of the middle term (M) in the premisss. The middle term may take the position of the subject or the predicate in both premisses. The first figure then assumes the following form: MP, SM; SP. If subject and predicate are connected by universally affirmative statements, this is indicated by a (i.e. "every x is" or "all x are"). The (mnemonic) pons asinorum (asses' bridge) Modus Barbara is so called because it contains three a's. Singular statements like "Socrates is a human being" were fitted into the syllogistic schema by treating them as A-statements (universally affirmative and therefore not particular). The statement "Socrates is a human being" (SM) is then translated into the syllogistic schema of SaM by transforming S into "All the things identical with Socrates".
[viii] CP 5.365: "The object of reasoning is to find out, from the consideration of what we already know, something else which we do not know."
[ix] See the excellent book by Ines Riemer (1988) which traces the development of Peirce's views of induction from a "theory of discovery" to a "theory of corroboration" and shows with great clarity how Peirce finally arrived at his understanding of abduction. My presentation of Peirce's theory of induction is based on Riemer's work.
[x] Peirce, therefore, correlates the three main tasks of science with the three types of inference: "1) the discovery of laws, which is accomplished by induction; 2) the discovery of causes which is accomplished by hypothetic inference, and 3) the prediction of effects which is accomplished by deduction" (CP 2.713; see also Riemer 1988, p. 23f.).
[xi] Peirce later changes the categorical syllogism to a conditional one, cf. for instance CP 5.189: "The surprising fact, C, is observed. But if A were true, C would be a matter of course. Hence, there is reason to to suspect A is true..." Thus it becomes obvious that the abductive model may be interpreted according to the Hempel-Oppenheim-Popper schema. (The general law being "If A, then C", the abduction of the case A would mean inferring the antecedent.)
[xii] Peirce writes: „The abductive suggestion comes to us like a flash. It is an act of insight, althoug of extremely fallibel insight. It is true that the different elements of the hypothesis were in our minds before; but it is the idea of putting together what we had never before dreamed of putting together which flashes the new suggestion before our contemplation.“ (CP 5. 180)

[xiii] Cf. Wittgenstein: "Isn`t it like this:so long as one thinks it can´t be otherwise, one draws logical conclusions.... The steps which are not brouht in question are logical inferences.. But the reason why they are not brought in question is not that they „certainly correspond the truth“ - or something of the sort , - no, it ist just this that is called ´thinking´, ´speaking´, ´infering´, ´arguing´. There is not any question at all here of some correspondence between what is said and reality; rather is logic *antecedent* to any such correspondence; in the same sense, that is, as that in which the establishment of a method of measurement is antecedent to the correctness or incorrectness of a statement of length." (BGM, p.45e, 96e, § 155 and §. 167).

[xiv] There are many affinities here with Wittgenstein's philosophy of logic, and grammar, respectively, which I can only point to in passing. In the terminology of the later Wittgenstein one would, of course, have to say that the grammar, i.e. the form of the representation or description of reality, has changed. (Cf. Fischer 1987, 1999a, b.)

[xv] Eco, disregarding the sign-using subject, puts it in the following way: "Abduction, therefore, is the experimental and risk-laden searching-out of a system of rules of signification which make it possible for a sign to gain its meaning(s)." (Eco 1985, p.68) Several types of abduction may be distinguished depending on whether and how the hypothetical rule which is inferred from the result is known or not. Of particular importance is the type of creative abduction when the explanatory hypothesis (rule) has yet to be invented, as is the case with paradigm changes such as Peirce himself describes. "Over-coded abduction" characterizes the ordinary everyday interpretation of signs: the rule of interpretation is quasi-"automatically" made available to the sign users by the context enabling them to attribute meaning to the signs. Cf. Eco 1985, p. 69ff, who relates his account to other authors. Cf. also Keller 1995.

[xvi] Rudi Keller distinguishes the primarily deductive reasoning processes of the sender (speaker) from those of the hearer in the communication process. Cf. Rudi Keller 1995.

[xvii] "I should tire you if I dwelt further on anything so familiar, especially to every psychological student, as the interpretativness of the perceptive judgment. It is plainly nothing but the extremes case of Abductive Judments“ CP 5.184. Cf. also „...abductive inference shades into pereceptual judment without any sharp line of demarcation between them; or, in other words, our first premisses, the perceptual judgments, are to be regarded as an extreme case of abductive inferences, from which they differ in being absolutely beyond criticism“(CP 5.181).

[xviii] Peirce demonstrates this by means of various examples, e.g. Kepler's attempt to establish the orbit of the planet Mars (SS 1, p. 393f.).

[xix] Let me simply state here without further discussion that Peirce, with his theory of abduction, seeks to clarify and/or to reconstruct no more than the logical form that is required for a synthetic inference which is to increase our knowledge. Peirce cannot explain, how and why such hypotheses emerge in the minds of human beings. He therefore talks about abduction as a kind of guessing, as a strange "guessing instinct" with which humans are endowed and which makes human constructions fit nature more often than not. He tries to circumvent the question why many of our hypotheses (abductions) prove to be correct above chance level, i.e. fit nature, by means of a hopeful but, in the last resort, metaphysical postulate, namely by claiming an affinity between the reasoning human mind and nature. Cf. CP 1.121, 5.173.

[xx] Peirce presents the form of the 3rd kind of inference, which he first named "hypothesis" and which then became abduction, in the following manner:

"Any M is, for instance P', P", P"', etc.

S is P', P", P"', etc.;
∴ S' is probably M" (CP 2.511).

There are two characteristic aspects of Peirce's conception of his hypothesis (developed from the 3rd kind of inference: MP, SP, SM). (1) Its content-increasing character is the result of an inference from given properties of a subject (P', P", P"' etc.) to other predicates of the subject (S) which are not implicitly inherent in S, so that in conclusion the subject S can be assigned the predicate M. (2) The derived statement (the minor premise in the syllogism) S is M may be taken to be the cause of the phenomenon "S is P". The first aspect was later called "qualitative induction" by Peirce (cf. Riemer, op. cit., p. 32-44) and separated from abduction. From about 1903 Peirce delimited the concept of abduction by claiming that the content-enlarging quality of this mode of inference consisted not in an "induction of characters", but in that the inferred cause (S is M) represented a completely novel statement. Correspondingly, he sees the function of abduction in the discovery (or invention) and formulation of new hypotheses (cf. Riemer, op. cit., p. 33). For the distinction between qualitative induction and abduction cf. also Karl-Otto Apel's note 3 in his edition of Peirce's writings on pragmatism and pragmaticism, Peirce 1991, p.81.

[xxi] Peirce pointedly expresses this insight: "Every judgment, therefore, being a reference of the experienced or known to the assumed or unknown, is an explanation of a phenomenon by a hypothesis, and is in fact an inference. Hence there is a major premise behind every judgment..." (Peirce, W I, p. 152)

[xxii] "...Thus the word'inference' may be useful precisely because it helps us to distinguish between self-critical and un-critical constructions of representations."(Peirce 1991 a, p. 332).

[xxiii] Cf. "The laws of logic are indeed the expression of ´thinking habits´ but also of the habit of *thinking*. That is to say they can be said to shew: how human beings think, and also what human beings call ´thinking´" (Wittgenstein RFM, p. 41, § 131) A few paragraphs later Wittgenstein corrects the formulation that the laws of thought express the "essence" of human thinking: "The porpositions of logic are ´laws of thought´, ´because they bring out the essence of human thinking´- to put it more correctly: because they bring ou, our she, the essence, the technique, of thinking. They shew what thinking is and also shew kinds of thinking." (ibid.). As rules, the "laws of logic" are neither true nor false but much rather practical or impractical. Wittgenstein thus argues pragmatically (cf. L II, p. 70). And what he has to say about mathematicians holds equally for logicians: "The mathematician is an inventor, not a discoverer." (RFM p. 45e, § 167)

[xxiv] Peirce had, in his information-theoretical reflections on induction and hypothesis (abduction), considered the idea that modes of inference which increase our knowledge must change the information content of concepts. The difference between inductive and hypothetical (abductive) inferences is, from the point of view of information theory, that with inductive inferences the extensional domain of the predicate of the conclusion grows without its intension becoming smaller (cf. W I, p. 271). With abduction (or: hypothesis) the intension of the concept of the subject of the conclusion increases, according to Peirce, without its extension becoming smaller. For a detailed logical analysis of the shifting of both extension and intension of concepts in abductive inferences cf. Fischer 2000. I pay no attention, though, to what Peirce called "qualitative induction" (initially hypothesis) and later abduction.

[xxv] As Wittgenstein keeps demonstrating in obsessive detail in his philosophy of mathematics (cf. RFM).

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