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PROBLEMS WITH PEIRCE'S CONCEPT OF ABDUCTION

ABSTRACT. Abductive reasoning takes place in forming "hypotheses" in order to explain "facts." Thus, the concept of abduction promises an understanding of creativity in science and learning. It raises, however, also a lot of problems. Some of them will be discussed in this paper. After analyzing the difference between induction and abduction (1), I shall discuss Peirce's claim that there is a "logic" of abduction (2). The thesis is that this claim can be understood, if we make a clear distinction between *inferential* elements and *perceptive* elements of abductive reasoning. For Peirce, the creative act of forming explanatory hypotheses and the emergence of "new ideas" belongs exclusively to the perceptive side of abduction. Thus, it is necessary to study the role of perception in abductive reasoning (3). A further problem is the question whether there is a relationship between abduction and Peirce's concept of "theorematic reasoning" in mathematics (4). Both forms of reasoning could be connected, because both are based on perception. The last problem concerns the role of instincts in explaining the success of abductive reasoning in science, and the question whether the concept of instinct might be replaced by methods of inquiry (5).

KEY WORDS: abduction, instincts, Peirce, perception, theorematic reasoning

1. WHAT IS THE DIFFERENCE BETWEEN INDUCTION AND ABDUCTION?

In his later writings, Peirce defines abduction, deduction and induction as different *steps* in the process of inquiry:

. . . there are but three elementary kinds of reasoning. The first, which I call *abduction* . . . consists in examining a mass of facts and in allowing these facts to suggest a theory. In this way we gain new ideas; but there is no force in the reasoning. The second kind of reasoning is *deduction*, or necessary reasoning. It is applicable only to an ideal state of things, or to a state of things in so far as it may conform to an ideal. It merely gives a new aspect to the premisses. . . . The third way of reasoning is *induction*, or experimental research. Its procedure is this. Abduction having suggested a theory, we employ deduction to deduce from that ideal theory a promiscuous variety of consequences to the effect that if we perform certain acts,

we shall find ourselves confronted with certain experiences. We then proceed to try these experiments, and if the predictions of the theory are verified, we have a proportionate confidence that the experiments that remain to be tried will confirm the theory. I say that these three are the only elementary modes of reasoning there are. (Peirce, 1905, ca., CP 8.209)

Abduction, thus, appears as the path from facts towards ideas and theories, while induction is the path from ideas and theories towards facts in order to obtain a basis for statistical assessment of the ideas' and theories' probabilities. "Abduction seeks a theory. Induction seeks for facts. In abduction the consideration of the facts suggests the hypothesis. In induction the study of the hypothesis suggests the experiments that bring to light the very facts to which the hypothesis had pointed" (Peirce, 1901b, CP 7.218). For the later Peirce, the problem of induction is not *what* can be generalized from a sample of data, but only a quantitative determination of what is already given by abduction. Thus, we get a concept of induction as *confirmation*, like Hempel's (cf. Goodman, 1983 [1954], p. 67).

In this context, I will not discuss the old and new "riddles of induction" (cf. also Stalker, 1994; with regard to Peirce, Harris and Hoover, 1983 [1980]). However, it is important to remember how Peirce saw the specific character of abduction as compared to induction: "*Abduction* is that kind of operation which suggests a statement in no wise contained in the data from which it sets out . . . By its very definition abduction leads to a hypothesis which is entirely foreign to the data" (Peirce, 1901c, LOS, pp. 898f.). There is no direct way – and not even a probabilistic one (cf. Peirce, 1902b, CP 2.102; Peirce, 1898, CCL 193) – from a set of data towards an organizing structure or explanatory hypothesis for such data. In Hans Reichenbach's terminology, we might say that induction hints at the problem of justification of general assertions while abduction is concerned with the problem of discovery. Harris and Hoover (1983 [1980]) describe the point as follows (numbers refer to Peirce, CP):

As an inference, induction has the psychological effect of fixing belief in a certain hypothesis. It becomes ever more difficult to doubt the truth of a hypothesis that is confirmed in ever more instances (2.96, 7.218). Logically, on the other hand, induction has a less powerful role. Every induction tests the conclusion of some abduction, and provides the grounds for supporting it. Because abduction suggests a hypothesis only in response to some surprising fact, there is, for any properly drawn hypothesis, already some positive support. The lack of any positive support,

then, provides grounds *ipso facto* on which to doubt the hypothesis. Nevertheless, the role of induction is only to give an opportunity for nature to refute or falsify a hypothesis. No number of positive instances can demonstrably prove that a hypothesis is true (2.663). (pp. 134f.)

Let us consider the following example. Under the heading of "Records on the Cinder Track: Women are Catching up," a German news magazine showed an impressive figure of a statistic seven years ago concerning the running speed increase for men and women in Marathon races (DER SPIEGEL 3/92). The data of running speed over the last 40 years were connected by a straight line and a forecast was made which suggested that the significantly faster increase of women's running speed in the past will entail that women will run faster than men in 1998. A wonderful perspective for the future as well, even if this forecast has not been verified as yet. But let us take a closer look at the data measured (cf. Figure 1).[1]
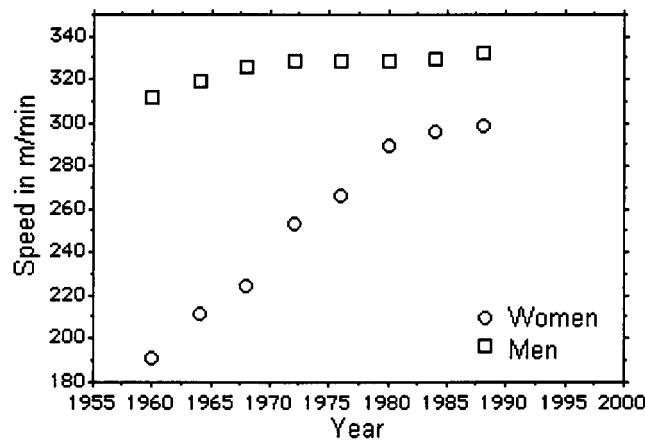

Figure 1.   The individual data.

If these data are connected by a regression line, the running speeds intersect already in 1994 (cf. Figure 2).

If one tries, however, to link the data with an intuitively constructed regression curve, this results in Figure 3 which seems much more credible.

The data for themselves give no answer to the question which is the more appropriate means of representation. Sets of data can be described by very different functions or laws, as every empirical scientist knows, and any mathematical function can be continued
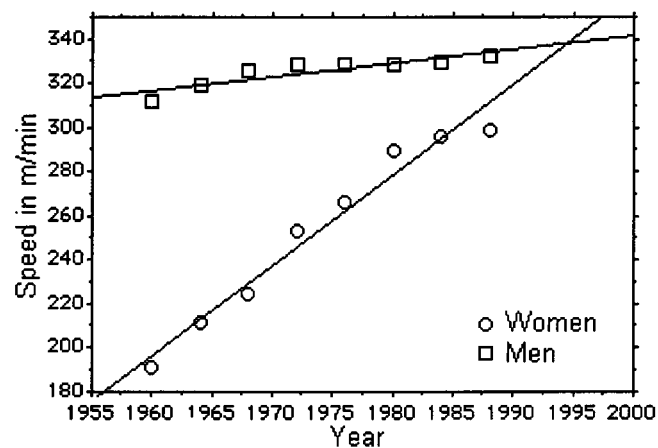
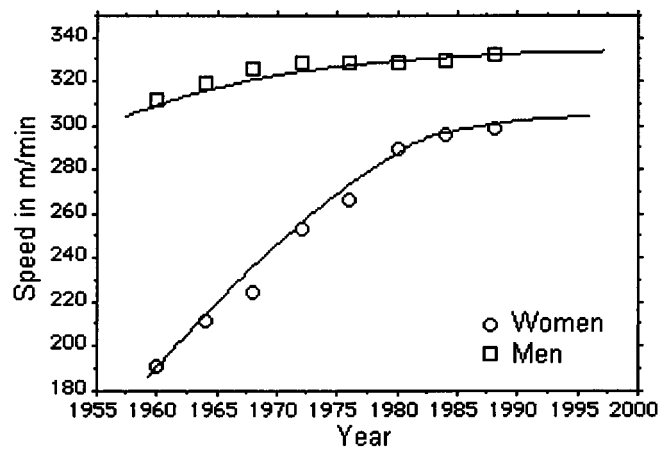*Figure 2.* Prognosis by means of a regression line.

Figure 3. Prognosis by means of a regression curve.

in infinitely many ways (cf. Otte, 1998a, p. 69). There is no logical way from the data towards a certain general form of representing the data, as Hume has already seen very clearly. Also statistical techniques give no answer to the question which representation permits an adequate forecast. The hypothesis we form in order to represent the data is, as Peirce said, "in no wise contained in the data from which it sets out," even if the representation is of course not independent of the data. Using an earlier definition of abduction, we can say with Peirce that it "infers from facts of one kind to facts

of another" (Peirce, 1878, CP 2.642). Curve and line are *general* forms, while the measured data are *particulars* in that example.

In this way it seems to be clear that the problem of "abduction" is nothing but what is commonly called the problem of "induction." But the essential advantage of Peirce's approach of distinguishing the two concepts can be seen in the fact, which is evident from our example, that we are confronted with *two* problems and not only with one. It is *one* thing to imagine possible representations or interpretations for a set of data, and it is *another* thing to confirm or refute hypothetically assumed representations and interpretations. For abduction, it is clear that the problem of an adequate description goes beyond the scope of logic and mathematical techniques. It is an *epistemological problem*, a problem of our knowledge about the world, to find an adequate representation. In designating the second prognosis as "more credible," we recur to additional assumptions or hypotheses about the world that have nothing to do in a direct way with the naked data.

2. IS THERE A "LOGIC" OF ABDUCTION?

Peirce maintains that abduction is a form of "logical" inference: "Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea" (Peirce, 1903a, CP 5.171; cf. also Peirce, 1901–2/1911, CP 2.777) Two questions arise at once: what kind of "logic" must be assumed as including abductive reasoning, the process of generating a hypothesis, and in which way might this process be described as "logical"?

Let us begin with the first question. It is the merit of Heijenoort (1967) that, with his famous distinction between "Logic as Calculus and Logic as Language," he presented an instrument for distinguishing two major traditions in modern logic, the first built by Boole, De Morgan, and Schröder, and the second by Frege, Russell, Wittgenstein, and others. While, for the first group, logic "remains the study, in ordinary language, of algebraic relations between propositions," Frege's picture of logic is guided by a conception that emphasizes "the *universality* of logic". With Frege, logic became a universal language, while Boole's "universe classes" and De Morgan's "universe of discourse" are contexts that "can be changed

at will. The universe of discourse comprehends only what we agree to consider at a certain time, in a certain context. For Frege it cannot be a question of changing universes. One could not even say that he restricts himself to one universe. His universe is *the* universe" (ibid., p. 325). In a similar way, Hintikka (1997c) distinguishes "*language as the universal medium* (or *the universality of language*) and *language as calculus* (or *the model-theoretical view of language*)," where "language is like a calculus in that it can be freely assigned a new interpretation" (ibid., p. 14f.).

Hintikka (1997c) shows that Peirce belongs to the group around Boole, De Morgan, and Schröder, while Quine, for instance, must be counted among the other group. This decision is motivated in Hintikka's view by Peirce's greater emphasis on "operations of inference" than on "a universal language for mathematicians".[2] For Peirce indeed, choosing a "universe of discourse" is the first step of representing logical relations.[3] Peirce's contributions to the formal side of modern logic are well-known today (cf. Putnam, 1982; Quine, 1995; Dipert, 1995; Hammer, 1996; Houser et al., 1997), but Hintikka shows that for Peirce the discussion of "formal rules" is only the second step after a more fundamental interpretation of inferences, and that both steps are based on semantic considerations (ibid., p. 18); "formalism was a servant, not the master" (p. 22). Peirce's major interests were philosophy of logic and metalogical questions.

Hintikka's interpretation of Peirce's understanding of logic can be supported by using the results of many other studies. Thus, Nathan Houser summarized:

According to Peirce, logic, in its most general sense, is the formal science of representation or, as he sometimes said, the 'objective' study of thought. It is the general study of signs, a normative science, and is coextensive with semiotic (for Peirce, *semeiotic*).... From the standpoint of philosophy, Peirce's semiotic logic encompasses much, if not all, of epistemology, theory of inference and philosophical logic, and theory of interpretation and scientific method. (Houser, 1997, pp. 9, 11; cf. also Zeman, 1986, pp. 1f.; Tursman, 1987, pp. xi, 1–12; Dipert, 1995, pp. 50f.)

In 1882, Peirce defined the general conception of scientific logic as "the *art of devising methods of research*, – the *method of methods*" (Peirce, 1882, CP 7.59; cf. Fann, 1970, p. 23f.), and in a Baldwin's *Dictionary* article-written together with Christine Ladd-

Franklin-Peirce called "the real aim" of *exact* logic "to find an indisputable theory of reasoning by the aid of mathematics" (Peirce and Ladd-Franklin, 1901–2/1911, CP 3.618; cf. Peirce, 1902c, CP 4.227).

It is hardly possible to get a complete overview concerning the many ways Peirce used the term "logic," but it is clear that his concept of logic cannot be reduced to that of the Frege-Russell-tradition. With regard to our second question, however, concerning the "logical" character of abduction, the situation is even worse. On the one hand, particularly this point was changed by Peirce himself much more than others in his life-long efforts.[4] On the other hand, even Peirce seems to be undecided when he says that it "is equally easy to define inference so as to exclude or include abduction" (Peirce, 1901c, LOS, pp. 899). In this context, the only reason for including abduction is Peirce's claim that "all the objects of logical study have to be classified," and "that neither deduction nor induction can ever add the smallest item to the data of perception; ... All that makes knowledge applicable comes by the way to us *via* abduction." It seems to be a rather arbitrary decision to define the act of forming hypotheses as an object of "logical study," thus classifying it as a "logical operation." This decision, of course, depends on a broad conception of "logic," as suggested above.

In the literature about the "logicality" of abduction, we are confronted with two strategies. On the one hand, there is the attempt to reduce abduction exclusively to a type "of tasks involved in inquiry" (Levi, 1997, p. 52), i.e. to *heuristics*, connected with the thesis that "Peirce extended his conception of logic to include methodological questions" (ibid., pp. 35, 52; cf. Tursman, 1987, pp. xi, 2ff.). In this way, "logic" and "methodology" are merged, a distinction between the two seems impossible. On the other hand, there is also the strategy presented in a few articles by Tomis Kapitan, who argues that "the *inferential* procedures characterizing abductive discovery do not transcend deductive or inductive methods,... while the *heuristic* strategies that do are not rules of inference" (Kapitan, 1992, p. 3). Kapitan tries to show that abductive methods "for generating and preferring hypotheses fail to be autonomous from either a logical or an epistemological point of view," claiming that the value of Peirce's abductive reasoning lies

in its "*practical* character" alone (ibid.). The result of both strategies is that the logical character of abduction disappears somewhere.

This consequence, however, is not necessary. If we look more precisely at Peirce's considerations about the "perfectly definite logical form" of abduction he presents in his *Lectures on Pragmatism*, we see that a solution of the problem is possible by means of a clear distinction between the logical or inferential *form* of abductive reasoning and – as a *precondition* of this reasoning – the genuine *creative act* of "perceiving" possible explanatory hypotheses. One consequence of this interpretation will be that we obtain, with Peirce's abduction, the rather paradoxical conception of a "logical inference" that is conceivable without logical rules (cf. Peirce, 1903a, CP 5.188, and CP 7.220n). The famous "perfectly definite logical form" of abduction is the following:

(P1)   The surprising fact, C, is observed;

(P2)   But if A were true, C would be a matter of course,

(C)   Hence, there is reason to suspect that A is true (Peirce, 1903a, CP 5.189).

As Peirce states completely rightly, according to this form "A cannot be abductively inferred, or if you prefer the expression, cannot be abductively conjectured until its entire content is already present in the premiss, 'If A were true, C would be a matter of course'" (ibid.). That means, however, that the logical form for itself leaves the question unanswered *how to get the hypothesis "A"*. And that, even though Peirce has explicitly claimed a few lines before that abduction is "the operation of adopting an explanatory hypothesis." But for Peirce, as for any other logician who grounds validity of inferences on formal considerations alone, a "logical connection" cannot exist with regard to a "wholly new element" in the conclusion (ibid., CP 5.192). That implies: "quite new conceptions cannot be obtained from abduction" (ibid., CP 5.190).

In a rather dark argument Peirce uses "the distinction between the matter and the logical form" in order to show that "the entire logical matter of a conclusion must in any mode of inference be contained, piecemeal, in the premisses. Ultimately therefore it must come from the uncontrolled part of the mind, because a series of controlled acts must have a first" (ibid., CP 5.194). The essential

point seems to be that, as a consequence of the *excluded* possibility that the "new" elements "first emerge in the conclusion of an inference," it must be assumed that they are "given" in some way "in a perceptive judgment" (ibid.). This perceptive judgment is the ground of the *premisses* and not of the conclusion (cf. also Kapitan, 1997, p. 483). In this way, the *logic* of abduction would have nothing to do with forming, creating or adopting hypotheses, but only with the *form* of inference mentioned above. And this "logical form" of abductive inference enters the stage not before the original *creative act* is completed – in a "perceptive judgment":

The first emergence of this new element into consciousness must be regarded as a perceptive judgment. We are irresistibly led to judge that we are conscious of it. But the connection of this perception with other elements must be an ordinary logical inference, subject to error like all inference. (Peirce, 1903a, CP 5.192)

That the emergence of "new ideas" for Peirce indeed has to be located in the genesis of the second premiss mentioned above, becomes also clear from a passage that he decided to skip in his *Lectures on Pragmatism*:

A mass of facts is before us. We go through them. We examine them. We find them a confused snarl, an impenetrable jungle. We are unable to hold them in our minds. We endeavor to set them down upon paper; but they seem to be so multiplex intricate that we can neither satisfy ourselves that what we have set down represents the facts, nor can we get any clear idea of what it is that we have set down. But suddenly, while we are poring over our digest of the facts and are endeavoring to set them into order, it occurs to us that if we were to assume something to be true that we do not know to be true, these facts would arrange themselves luminously. That is *abduction* . . . (Peirce, 1903a, EP II, pp. 531f.)

The explaining idea emerges in *perceiving* facts and experiences, and *not* in the conclusion of an inference. In this way, the paradox mentioned above – that Peirce confronts us with a conception of abduction as "logical inference" that is "very little hampered by logical rules" (Peirce, 1903a, CP 5.188) – can be explained by distinguishing between the logical or inferential form of abductive arguments and the genuine *process* of "getting" an explanatory hypothesis. There is a form of inference, but there are no rules for getting a hypothesis.

Peirce himself distinguished the *logical* or *inferential* side of abduction from its creative side by distinguishing self-controlled

"reasonings from the processes by which perceptual judgments are formed," and by claiming that "self-control of any kind is purely inhibitory. It originates nothing" (Peirce, 1903a, CP 5.194). For that, I think, it is necessary to make a terminological distinction between "*inferential aspects of abduction*" and "*perceptive aspects of abduction*." While the inferential side is characterized by the whole syllogistic formula mentioned above, the perceptive side, i.e. the genesis of a perceptual judgment, in which a hypothesis of the form "If A were true, C would be a matter of course" firstly emerges, has to be located at the premises. In order to explain within Peirce's concept of "logic" abduction as "the process of forming an explanatory hypothesis," *both* sides must come together.

The main line of my argument is supported by the interpretation of Tomis Kapitan, who shows that "valid abductive reasoning does not sanction inference to a novel hypothesis (specifically, abduction is not inference *to* the best explanation)," and that "the initial conceiving of a novel hypothesis is not the product of an *inferential* transition" (Kapitan, 1992, p. 2). Referring to Peirce's 1903 *Lectures on Pragmatism*, too, he also concludes "that the hypothesis initially emerges in the *observation* of the colligated whole through an uncontrolled insight into the world of ideas" (Kapitan, 1997, p. 483). I cannot see, however, the sense of his theses that "every inferential phase of the abductive process can be analyzed in terms of inductive or deductive methods," and that "there is no abductive correctness that cannot be reduced to deductive or inductive validity" (Kapitan, 1992, p. 2). What is "abductive correctness"? The inferential form of abduction – *if* there is a surprising fact, and *if* there is a hypothesis that would explain this fact, *then* it makes sense to test the hypothesis – is obviously not reducible to the form of deduction or induction, and why should every abductive inference that is formulated according to this form not be "correct"? The value or "uberty"[5] of the hypothesis, on the other side, is beyond the scope of the logical form, and it makes no sense to describe its genesis as correct or incorrect for it is beyond the limits of self-control.

Kapitan's attempt to show that all the premisses – i.e. the "phases" mentioned above – of an abductive inference are, in themselves, based on deductive or inductive inferences is not very convincing (Kapitan, 1992, pp. 7–11; Kapitan, 1997, pp. 482–5).

As we shall see in the next section, for example, the genesis of the second premiss – i.e. the perceptive part of abduction – indeed is conceived as the result of an *inference*. This inference, however, is not deductive but again *abductive*. An interesting question, however, concerns Kapitan's observation, that the

> ...*judgment* that a phenomenon is surprising is subsequent to the observation that it is contrary or improbable given what is expected ...But this judgment itself results from an inference ...Observation of what is contrary or improbable given what is expected, comes by focusing upon the relations between premises and conclusion. To 'see' that P is contrary to Q or improbable given Q, is to realize that either implies or makes likely $\sim P$, in which case the observation underlying a judgment of contrareity is exactly the sort that typifies deduction. Hence, the inference that the phenomenon is surprising, in want of explanation, appears to be deductive. (Kapitan, 1992, p. 7)

In a similar manner, in order to clarify what "surprise" in a more logical form might mean, Atocha Aliseda distinguishes as "triggers" of abductive reasoning the "*novelty*" of an observation or a belief φ with respect to a background theory θ and the "*anomaly*" of φ relative to θ (Aliseda, 1998). It is evident, as Kapitan says, that the "claim that a phenomenon is surprising is intelligible only against a body of background expectations" (Kapitan, 1992, p. 7), but the question is whether the notion of "surprise" really is necessary to describe abduction. If we take our example of the marathon race – or Peirce's approach of explaining perception as abductive inference as I shall discuss in the next section, – we have to concede that there is neither surprise nor contradiction between background theory and facts or observations. The problem of abduction in these cases is: How to obtain an idea, a theory, or a hypothesis that allows a *representation* of "facts," of data, or of *particulars* of any ideal or empirical kind. There need not be a fixed "theory" against that facts would be surprising. The concept of abduction makes sense also in situations where we only indefinitely feel a need of representing something in a certain order.

The solution of the problematic "logic of abduction" I suggest – i.e. that Peirce restricted *logicality* to the quoted formula that, in itself, does not say much, while reserving the *creativity* of abduction for the genesis of "perceptive judgments" – corresponds in a certain way to Douglas Anderson's considerations. Against Harry Frankfurt, who had noticed a fundamental paradox in "that Peirce

holds both that hypotheses are the products of a wonderful imaginative faculty in man and that they are products of a certain sort of logical inference" (Frankfurt, 1958, p. 594), Anderson emphasized that Peirce "quite explicitly states that abduction is both an insight and an inference. This is a fact to be explained, not to be explained away" (Anderson, 1986, p. 45). His explanation of this paradox leads to the claim: "Abduction involves both logic and psychology, but neither exclusively" (ibid., p. 54; cf. Peirce, 1902b, CP 2.107).

Anderson discussed this problem by referring to Peirce's theory of three fundamental categories, Firstness, Secondness, and Thirdness: On the one hand, "Abduction, in being a form of reasoning, is essentially a third," on the other hand, however, "in being the first stage, the sensuous form of reasoning, it is a first of a third of a third" (ibid., pp. 56f.). Anderson describes the firstness of abduction by the "freedom" of abductive reasoning as "the least controlled form of scientific reasoning," by the "free play" of ideas, by the fact that its "hypotheses are pure possibilities," and by its "spontaneity" and "originality" (ibid., pp. 57–61). From this point of view, "Abduction is inference because the agent is free to control his reasoning and it is insight because it allows ideas to suggest other ideas" (ibid., pp. 60f.). Thus abduction would be both: a free play of imagination and an inferential process.

We can now see that the *inferential* aspects of Peirce's concept of abduction cannot solve the riddle of abduction: how the *creative act* of forming or adopting hypotheses can be explained. I will therefore turn to the study of the "perceptive aspects of abduction" and of their role in scientific discoveries in greater detail.

3. HOW CAN THERE BE ANY "CREATIVITY" IN THE GENESIS OF PERCEPTUAL JUDGMENTS?

Peirce saw abduction at work in a wide range of situations. On the one hand, abduction is the basis of scientific discoveries.[6] On the other hand, he went so far as to say that abduction takes place when a chicken just born picks up the right sort of corn, and in any act of perception.

Looking out of my window this lovely spring morning I see an azalea in full bloom. No, no! I do not see that; though that is the only way I can describe what I

see. *That* is a proposition, a sentence, a fact; but what I perceive is not proposition, sentence, fact, but only an image, which I make intelligible in part by means of a statement of fact. This statement is abstract; but what I see is concrete. I perform an abduction when I so much as express in a sentence anything I see. The truth is that the whole fabric of our knowledge is one matted felt of pure hypothesis confirmed and refined by induction. Not the smallest advance can be made in knowledge beyond the stage of vacant staring, without making an abduction at every step.

When a chicken first emerges from the shell, it does not try fifty random ways of appeasing its hunger, but within five minutes is picking up food, choosing as it picks, and picking what it aims to pick. That is not reasoning, because it is not done deliberately; but in every respect but that, it is just like abductive inference. (Peirce, 1901c, LOS, pp. 899f.)

It seems to be clear that the chicken's behavior is not an act of deliberate reasoning. But then in which other sense can it be abductive? Is there any "process of forming an explanatory hypothesis" or "any new idea" that is introduced while picking corn and watching flowers? Keeping in mind, however, that it is an essential element of Peirce's pragmatism "that perceptual judgments contain elements of generality" (Peirce, 1903a, HLP 238; cf. the second "cotary proposition" of Pragmatism in Peirce, 1903a, CP 5.181), we may describe the genesis of perceptual judgments as the process of forming "hypotheses" in order to represent or to handle sense data. The general concept "azalea" is indeed, as Peirce said, "in no wise contained in the data from which it sets out," so that there is a *problem* how to get from sense data to perceptual judgments. This problem is just analogous to that of representing the data in our marathon example. For Peirce, abduction seems to be the solution of this problem.

In this way, however, we seem to be confronted with a *circulus vitiosus*. On the one hand, we have learned from the last section that the creativity of abduction is based in the genesis of perceptual judgments. On the other hand, we now hear that any perceptual judgment in itself is the result of an abduction! Or as Peirce says, "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" (Peirce, 1903a, CP 5.181).

As becomes clear from the azalea example, Peirce understands perception as a process of *subsuming* sense data or "percepts" under concepts or ideas that are in some way already *given*. In his *Lectures*

on Pragmatism, he uses a figure of his father that can be seen either as a serpentine line or as a stone wall:

The point is that there are two ways of conceiving the matter. Both, I beg you to remark, are *general ways of classing the line*, general classes under which the line is subsumed. But the very decided preference of our perception for one mode of classing the percept shows that this classification is contained in the perceptual judgment. (ibid., CP 5.183)

Such an act of subsuming percepts under general classes or ideas, of course, may be analyzed as an abductive inference. Peirce himself, twelve years earlier, gave the following formula of an abduction in perception:

(P1)   A well-recognized kind of object, M, has for its ordinary predicates P[1], P[2], P[3], etc., indistinctly recognized.

(P2)   The suggesting object, S, has these same predicates, P[1], P[2], P[3], etc.

(C)   Hence, S is of the kind M. (Peirce, 1891, CP 8.64)

Also in this abductive *inference* there is no "new idea" in the conclusion – in spite of its assertoric form Peirce emphasized that this "is hypothetic inference in form," – but the "creative" act takes place in the second premiss. That means, in short, the following: If we distinguish in abduction an *inferential part* and a *perceptive part*, i.e. the genesis of a perceptual judgment, and if we understand according to Peirce the coming up of a perceptual judgment for itself as an abductive inference, then we get an infinite regress in explaining the possibility of abduction. Just this infinite regress, however, or this recursive structure of abductive reasoning appears to be the major point in Peirce's concept of abduction:

On its side, the perceptive judgment is the result of a process, although of a process not sufficiently conscious to be controlled, or, to state it more truly, not controllable and therefore not fully conscious. If we were to subject this subconscious process to logical analysis, we should find that it terminated in what that analysis would represent as an abductive inference, resting on the result of a similar process which a similar logical analysis would represent to be terminated by a similar abductive inference, and so on *ad infinitum*. This analysis would be precisely analogous to that which the sophism of Achilles and the Tortoise applies to the chase of the Tortoise by Achilles, and it would fail to represent the real process for the same reason. Namely, just as Achilles does not have to make the

series of distinct endeavors which he is represented as making, so this process of forming the perceptual judgment, because it is subconscious and so not amenable to logical criticism, does not have to make separate acts of inference, but performs its act in one continuous process. (Peirce, 1903a, CP 5.181)

Thus, two points seem to be essential for Peirce's conception of abduction: on the one hand, the infinite recursiveness of the inferential and the perceptive part of the abductive process – the second premiss of an abductive inference, i.e. the perceptive part of abduction, is the result of an abductive inference whose second premiss again is the result of an abductive inference, etc., – and on the other hand, the *continuity* of this process. The astonishing fact is that, while logic necessarily seems to be *discrete* – self-controlled reasoning step by step, Peirce's logic of abduction depends on the continuity of an unconscious process. But the point is now: can this consideration be sufficient to explain the *creativity* of abductive reasoning and the emergence of "new ideas"?

A further consideration seems necessary. I have no explicit support in Peirce's writings for the following hypothesis, and there are many problems connected with this 'abductive suggestion', but my starting point is Peirce's claim that in abduction "the entire logical matter of a conclusion ... must come from the uncontrolled part of the mind" (ibid., CP 5.194). We have seen the significance of perception for Peirce's theory of abduction, we have noticed that for him "elements of generality" are "contained in the perceptual judgment," (ibid., CP 5.183) and that perception in some way is conceptualized as subsumption of sense data under "given" ideas. But where did those "given" ideas come from? The specific character of Peirce's "ideas" and *all general forms* is their vagueness, their continuity, their character of possibility, their lack of identity, the not-applicability of the logical principle of the excluded middle, i.e. the tertium non datum, and – in one word – their "Firstness":[7]

An idea cannot actually be said to have any identity. Two ideas may be indefinitely alike and if so, they are *nearly the same*. If they are just alike, they are exactly the same. Ideas have no *hic and nunc*, no *hecceity*, by which they could be *this* and *that* independently of their likeness to one another. Since every idea, A, is in itself more or less vague, an idea, B, may be so like it that A and B are in themselves indeterminate in respect to being exactly the same or only very nearly the same. Indeed, it is impossible that A and B should be determinately exactly the same

and not merely very nearly the same. The vagueness of every idea deprives it of absolute identity even with itself. (Peirce, 1897, ca., MS 787 CSP 25)

As becomes clear in *The Law of Mind* (Peirce, 1892), Peirce's concept of "idea" seems to be connected with the Cartesian tradition in which an idea is more or less a "psychological" entity, *representatio*, a conception existing in the mind as a result of mental understanding (Kant would say: a *Vorstellung*). It is essential for Peirce "that ideas tend to spread continuously and to affect certain others which stand to them in a peculiar relation of affectibility. In this spreading they lose intensity, and especially the power of affecting others, but gain generality and become welded with other ideas" (ibid., CP 6.104). He emphasized again the continuity of ideas (CP 6.143). An idea is something that can be "directly sensed," ideas "rise up toward the surface of consciousness in numbers, so as to form something analogous to a composite photograph, called a *general* idea" (Peirce, 1897, ca., MS 787 CSP 25).

There being a continuous connection between the ideas, they would infallibly become associated in a living, feeling, and perceiving general idea. . . . I think we can only hold that wherever ideas come together they tend to weld into general ideas; and wherever they are generally connected, general ideas govern the connection; and these general ideas are living feelings spread out (Peirce, 1892, CP 6.143).

Suppose, for example, I detect a person with whom I have to deal, in an act of dishonesty. I have in my mind something like a 'composite photograph' of all the persons that I have known and read of that have had that character; and at the instant I make the discovery concerning that person, who is distinguished from others for me by certain indications, upon that index, at that moment, down goes the stamp of RASCAL, to remain indefinitely (Peirce, 1895, EP II, pp. 19f.).

In themselves considered any two sense-qualities are what they are to themselves alone and have no relation to one another. But could they be compared by a mind that brought no tinge of its own nature into the comparison, any two ideas would appear somewhat alike and somewhat different. But the human mind attaches a peculiar value and emphasis to some resemblances, and that consists in this, that when one quality is brought vividly to consciousness, others will at once have their vividness increased, some more, some less. Thus, an idea which may be roughly compared to a composite photograph surges up into vividness, and this composite idea may be called a *general idea*. It is not properly a *conception*; because a conception is not an idea at all, but a habit. But the repeated occurrence of a general idea and the experience of its *utility*, results in the formation or strengthening of that habit which is the conception. (Peirce, 1898, ca., CP 7.498)

In order to get some idea of what might be going on in forming a perceptual judgment from sense data, and of how an explanatory hypothesis might emerge during the perceptive part of abduction, I will quote a longer passage from a manuscript that – as far as I know – has as yet been published only in the Peirce Microfilm edition. In this passage, the context is not the problem of abduction but the claim that in every assertion there must be embedded – besides two other signs – also "a sign of the enforced idea." Thus, the theme ultimately is the possibility of communication, but we have to remember that for Peirce – as for Plato – thought is also conceived as communication, "a dialogue of the soul with itself."

Like ideas attract one another. That is, when one is brought near the surface of consciousness, it draws upward from the lower depths of consciousness other ideas like it, which as they come up, make their impress upon the composite. They must do so, for this attraction for one another is precisely what the likeness of ideas *consists in*. It is impossible to attach any other notion to the phrase likeness of ideas. Hence, it is not merely true of the *human* mind, but of any mind in which ideas have any likeness, that is, in any mind capable of *generalization*; and since all ideas are, in consequence of their want of hecceity, more or less vague, that is general, it follows that the law of attraction is true for every mind that has ideas. But what is a *mind* except a faculty for ideas?

An idea is called up where an idea sufficiently like it is called up. A representation of an idea is nothing but a sign that calls up another idea. When one mind desires to communicate an idea to another, he embodies his idea by making an outward perceptible image which directly calls up a like idea; and another mind perceiving that image gets a like idea. Two persons may agree upon a conventional sign which shall call up to them an idea it would not call up to anybody else. But in framing the convention they must have resorted to the primitive diagrammatic method of embodying the idea in an outward form, a picture. Remembering what likeness consists in, namely, in the natural attraction of ideas apart from habitual outward associations, I call those signs which stand for their likeness to them *icons*.

Accordingly, I say that the only way of directly communicating an idea is by means of an icon; and every indirect method of communicating an idea must depend for its establishment upon the use of an icon. Hence, every assertion must contain an icon or set of icons, or else must contain signs whose meaning is only explicable by icons. The idea which the set of icons (or the equivalent of a set of icons) contained in an assertion signifies may be termed the *predicate* of the assertion.

Turning now to the rhetorical evidence, it is a familiar fact that there are such representations as icons. Every picture (however conventional its method) is essentially a representation of that kind. So is every diagram, even although

there be no sensuous resemblance between it and its object, but only an analogy between the relations of the parts of each. Particularly deserving of notice are icons in which the likeness is aided by conventional rules. Thus, an algebraic formula is an icon, rendered such by the rules of commutation, association, and distribution of the symbols. It may seem at first glance that it is an arbitrary classification to call an algebraic expression an icon; that it might as well, or better, be regarded as a compound conventional sign. But it is not so. For a great distinguishing property of the icon is that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction. Thus, by means of two photographs a map can be drawn, etc. Given a conventional or other general sign of an object, to deduce any other truth than that which it explicitly signifies, it is necessary, in all cases, to replace that sign by an icon. This capacity of revealing unexpected truth is precisely that wherein the utility of algebraic formulae consists, so that the iconic character is the prevailing one. (Peirce, 1897, ca., MS 787 CSP 26-28)

In the last words, there seems to be summarized what is the second essential for Peirce's concept of abduction besides the infinite recursiveness: The continuous character of ideas and their tendency "to spread continuously and to affect certain others" offer the possibility of perceiving "unexpected" hidden ideas. In this way, there is no *creatio ex nihilo* in abduction, "new" ideas are only relatively new:

. . . every reasoning involves another reasoning, which in its turn involves another, and so on *ad infinitum*. Every reasoning connects something that has just been learned with knowledge already acquired so that we thereby learn what has been unknown. It is thus that the present is so welded to what is just past as to render what is just coming about inevitable. The consciousness of the present, as the boundary between past and future, involves them both. Reasoning is a new experience which involves something old and something hitherto unknown. (Peirce, 1899, ca.-b, CP 7.536)

"New" ideas emerge from what is already given in our minds; "it is the idea of putting together what we had never before dreamed of putting together which flashes the new suggestion before our contemplation," as Peirce said.[8] The possibility of "new" ideas depends – besides their continuity – essentially on analogies: "Nothing unknown can ever become known except through its analogy with other things known".[9] Analogies can be realized by what Peirce called "*association by resemblance*." To defend the "fundamental character" of this form of association against "association by contiguity," Peirce formulated the following argument:

Suppose I have long been puzzling over some problem, – say how to construct a really good typewriter. Now there are several ideas dimly in my mind from time, none of which taken by itself has any particular analogy with my grand problem. But someday these ideas, all present in consciousness together but yet all very dim deep in the depths of subconscious thought, chance to get joined together in a particular way such that the combination does present a close analogy to my difficulty. That combination almost instantly flashes out into vividness. Now it cannot be contiguity; for the combination is altogether a new idea. It never occurred to me before; and consequently cannot be subject to any *acquired habit*. It must be, as it appears to be, its *analogy*, or resemblance in form, to the nodus of my problem which brings it into vividness. Now what can that be but pure fundamental association by resemblance? (Peirce, 1898, ca., CP 7.498)

What exactly is going on, however, in such an act of "association" remains dark. It is like a "black box," but this speculative consideration seems to be a necessary basis of the perceptive part of abduction. A nice illustration might be the story of Mendeleev's discovery of the periodic table of chemical elements as described by Kedrov (1966–67 [1957]; cf. also Engeström, 1987, pp. 257–267). He remembers a later reflection of Mendeleev on his discovery, where he noted that he found the essential idea of connecting atomic weights and the specific properties of chemical elements

...by writing down the elements on separate cards with their atomic weights and fundamental properties, comparing elements that were similar in atomic weight, and quickly came to the conclusion that the properties of elements stand in periodic relation to their atomic weights ... (Kedrov, 1966–67 [1957], p. 25)

The idea of using cards, however, might have been possible for Mendeleev, as Kedrov suggests, by his love of playing the game of patience,

...where the thoroughly shuffled cards must then be rearranged according to definite rules, resulting in a definite pattern of disposing them by suit and denomination. The analogy with the distribution of elements turns out to be nearly complete; for at the moment when he considered this problem, two incomplete tables of elements were already written down on paper, and in them was already clearly charted a distribution of elements in two dimensions: horizontally, according to their general chemical properties or chemical similarity (which corresponds to arranging the playing cards according to suit), and vertically, according to the closeness of their atomic weights (which corresponds to arranging the playing cards by denomination). To shift from writing down tables on paper to preliminary distributions of the elements on cards as in patience required

only one thing more – to connect the task of arranging the elements in a table with the task of playing patience. (p. 24)

The atomic weights and the properties of elements were already known. The essential idea, however, that allows a classification of all elements, and even of those that had been discovered years later, was motivated by an "association by resemblance."

4. ABDUCTION AND "THEOREMATIC REASONING"

Asking in a broader sense for "creativity" in scientific reasoning, one finds in Peirce another important concept, the concept of "theorematic reasoning," that is of special importance in mathematics. With regard to abduction the difference is, firstly, that for Peirce "theoric" or "theorematic" reasoning is a kind of *deduction*, so that it is located in another branch of the *trivium* of abduction, deduction, and induction.

Deductions are either *Necessary* or *Probable*. Necessary Deductions are those which have nothing to do with any ratio of frequency, but profess (or their interpretants profess for them) that from true premisses they must invariably produce true conclusions. A Necessary Deduction is a method of producing Dicent Symbols by the study of a diagram. It is either *Corollarial* or *Theorematic*. A Corollarial Deduction is one which represents the conditions of the conclusion in a diagram and finds from the observation of this diagram, as it is, the truth of the conclusion. A Theorematic Deduction is one which, having represented the conditions of the conclusion in a diagram, performs an ingenious experiment upon the diagram, and by the observation of the diagram, so modified, ascertains the truth of the conclusion. (Peirce, 1903, ca.-a, CP 2.267; cf. Peirce, 1901b, CP 7.204)

Corollarial deduction is where it is only necessary to imagine any case in which the premisses are true in order to perceive immediately that the conclusion holds in that case.... *Theorematic deduction* is deduction in which it is necessary to experiment in the imagination upon the image of the premiss in order from the result of such experiment to make corollarial deductions to the truth of the conclusion. (Peirce, 1902a, NEM IV: 38)

On the one hand, any "*Corollary* ... would be a proposition deduced directly from propositions already established without the use of any other construction than one necessarily suggested in apprehending the enunciation of the proposition" (Peirce, 1903, ca.-b, NEM IV

288). Thus, also "logical machines" can perform corollary reasoning (Peirce, 1907a, MS 318: CSP 49=ISP 41). The point of "theoric" reasoning, on the other hand, consists "in the transformation of the problem, – or its statement, – due to viewing it from another point of view" (Peirce, 1907a, MS 318: CSP 68=ISP 225). Peirce takes the term "theoric" from the Greek "$\theta\varepsilon\omega\rho\acute{\iota}\alpha$" (theory) which he translates as "the power of looking at facts from a novel point of view" (ibid., CSP 50=ISP 42).

For Peirce, "the demonstration of every considerable theorem of mathematics affords an instance" of theorematic reasoning (ibid.). As an example he often hints at the discovery that the "Ten points theorem" (i.e. the two-dimensional case of Desargue's theorem) is easily provable when the representation of the problem is seen as a *perspective* representation. In this proof, "(e)verything is corollarial except the single idea that the plane figure is a projection of a figure in three dimensional space. That is certainly not corollarial, since there is nothing in the problem to suggest it, – no reference to a third dimension" (ibid., CSP 53; cf. Peirce, 1887, NEM III: 630; Peirce, 1909, NEM III: 870 f.).

Levy (1997) analyzes some further examples of corollarial and theorematic reasoning and develops from these examples a classification of different forms of mathematical reasoning, also connecting it with the traditional "analytic/synthetic distinction." Thus, he can correct in a certain way – following an argument of Ketner (1985) – Hintikka's interpretation, for whom "theorematic inference is characterized by the introduction of auxiliary individuals into the argument." Hintikka emphasized the "coincidence" between Peirce's view and his own distinction between "non-trivial and trivial logical arguments (surface tautologies and depth tautologies)." Even if this interpretation might restrict a multitude of different forms of theorematic reasoning to only one, it is Hintikka's merit to be the first having seen the "contemporary relevance" of Peirce's distinction between corollarial and theorematic reasoning against "a strong tradition in the philosophy of logic and mathematics which denies the possibility of any general logical distinction which like Peirce's turns on the concept of construction" (Hintikka, 1983 [1980], p. 109). In a recent paper on "Creativity in Reasoning," Hintikka continues this argumentation, starting by emphasizing the

relevance of a distinction between "*definitory* rules" and "*strategic* rules" in deductive reasoning, and arriving at a concept of "logical inference as experimental model-building" that can be seen in the tradition of Peirce's "diagrammatic reasoning" (Hintikka, 1997b). In this paper, however, Hintikka also concentrates his efforts on "introducing new individuals" as the core of theorematic reasoning, objects that "are introduced by linguistic (symbolic) descriptions" and not "iconically."

Against Hintikka's approach, Ketner (1985) had already emphasized the fundamental role of "visual observation" and iconicity in theorematic reasoning. To support this interpretation, I will add a few quotes from Peirce's writings:

It has long been a puzzle how it could be that, on the one hand, mathematics is purely deductive in its nature, and draws its conclusions apodictically, while on the other hand, it presents as rich and apparently unending a series of surprising discoveries as any observational science. Various have been the attempts to solve the paradox by breaking down one or other of these assertions, but without success. The truth, however, appears to be that all deductive reasoning, even simple syllogism, involves an element of observation; namely, deduction consists in constructing an icon or diagram the relations of whose parts shall present a complete analogy with those of the parts of the object of reasoning, of experimenting upon this image in the imagination, and of observing the result so as to discover unnoticed and hidden relations among the parts. (Peirce, 1885, CP 3.363)

...mathematics mainly consists in constructing diagrams (continuous in geometry, arrays of signs in algebra) according to general precepts and then observing in the parts of these diagrams relations not explicitly required in the precepts. All necessary reasoning depends upon such observation – a fact which could easily escape attention as long as logicians studied only syllogistic reasoning, where there is but one conclusion from given premises, which may be produced from them by a machine, but which becomes very obvious in the logic of relatives, where any premise whatever will yield an endless series of conclusions, and attention has to be directed to the particular kind of conclusion desired. (Peirce, 1899, ca.-a, LOS, pp. 1123)

The creativity of theorematic reasoning and the role of observation in it support the interpretation that there must be, for Peirce, a connection between this form of deductive reasoning and abduction. Both, at least, seem to fulfill the same task. What theorematic deduction is for mathematics, abduction seems to be for scientific discoveries in general. Thus, Ketner (1985) maintained "that production of

experiments within theorematic reasoning, on Peirce's view, is done through abduction" (p. 411; cf. also Eisele, 1982, p. 337; Tursman, 1987, p. 69; Crombie, 1997, p. 465). I have spent some effort to find in Peirce's writings hints at such a connection between abduction and theorematic reasoning, but without much success. Only in a manuscript mentioned by Levy (1997, p. 106) and Kapitan (1997, p. 482), we find the following interesting statement in which Peirce distinguished a "corollarial" and a "theoric" part *within* "theorematic reasoning":

But further study leads me to lop off a corollarial part from the Theorematic Deductions, which follows that part that originates a new point of view. This part of the theorematic procedure, I will call *theôric* reasoning. It is very plainly allied to retroduction, from which it only differs as far as I now see in being indisputable.[10]

In another passage of this manuscript, Peirce said that he "would regard the great hypotheses of pure mathematics ... as coming to us through retroduction from considering what for want of a better word I may call the facts of mathematics" (Peirce, 1907b, MS 754 ISP 3). However, there are two possible interpretations of this statement: either he *identified* abduction/retroduction and theoric reasoning here or he claimed that there is abduction in mathematics beyond theoric deduction. In a later text he concedes only some similarity at a certain point:

Deduction has two parts. For its first step must be by logical analysis to Explicate the hypothesis, i.e. to render it as perfectly distinct as possible. This process, like Retroduction, is Argument that is not Argumentation. But unlike Retroduction, it cannot go wrong from lack of experience, but so long as it proceeds rightly must reach a true conclusion. (Peirce, 1908b, CP 6.471)

The point of similarity seems to be that the essence of both theorematic reasoning and abduction cannot be found in any syllogistic form. More interesting in the last quote, however, is the emphasis on the *differences* between both. Whereas abduction is restricted – as Peirce said in another text – to furnishing "all our ideas concerning *real things*, ... Deduction ... relates only to *ideal objects*" (Peirce, 1905, ca., CP 8.209, italics are mine). This implies that, while deduction is *apodictic* and truth preserving reasoning (cf. Peirce, 1902c, CP 4.233), abduction only infers guesses from

guesses. *When* we have found in theorematic reasoning a new perspective, or *when* we have "added" something else to our diagram and "the conclusion appears" (Peirce, 1909, NEM III: 870), this conclusion is as apodictically true as any corollarial deduction. In abduction, however, if we guess that a certain curve A might describe our measured data of marathon races, and if we infer from this guess that "there is reason to suspect that A is true," that conclusion is as hypothetic as the guess of the premiss.

Summarizing our observations, we might conclude that abduction and theorematic reasoning are *similar* regarding the role of observation and what we have called the perceptive aspect of abduction, while they differ in form of inference and in apodicticity of possible conclusions. With regard to mathematics, further on, it is remarkable that Peirce defined the task of theorematic thinking to find an appropriate proof of an *already given theorem* (Peirce, 1901b, CP 7.204). It is part of the " 'preparation' for the demonstration" of a theorem according Euclid's famous procedure (Peirce, 1908c, CP 4.616). Contrary to this, the task of abduction might be first to formulate such a theorem. This is supported by the quote above regarding "the great hypotheses of pure mathematics" that come to us through abduction.

It is one thing *to prove* a theorem and another to *formulate* it, even if it might again be necessary for proving a theorem to formulate further theorems. Thus, it would make sense to describe the first task as *theorematic deduction* and the second task as abduction. With regard to abduction in mathematics, the reader is invited to try some experiments with an example developed by Otte (1998b) at http://www-cabri.imag.fr/Preuve/Newsletter/980708.html. If you click at the figures presented there, you can move certain points of geometrical diagrams. You will find yourself confronted with surprising mathematical "facts" that will give you an idea of abduction in mathematics.

5. INSTINCTS OR METHODS AS BASIS FOR THE SUCCESS OF ABDUCTIVE REASONING?

There are quite a lot of texts where Peirce explained the possibility of abduction by an "instinctive power",[11] or by an instinct-based

"rational insight into nature" (Peirce, 1901c, LOS, pp. 900; cf. Peirce, 1905a, S&S 187). The problem he tried to solve is: to explain the obvious success of abductive reasoning in the history of science and the rate of scientific progress in the face of the fact that for every set of data there exists in principle an infinity of possible explanations or possible representations. "But as for explaining evolution by chance, there has not been time enough" (Peirce, 1903a, CP 5.172).

How was it that man was ever led to entertain that true theory? You cannot say that it happened by chance, because the possible theories, if not strictly innumerable, at any rate exceed a trillion – or the third power of a million; and therefore the chances are too overwhelmingly against the single true theory in the twenty or thirty thousand years during which man has been a thinking animal, ever having come into any man's head. Besides, you cannot seriously think that every little chicken, that is hatched, has to rummage through all possible theories until it lights upon the good idea of picking up something and eating it. On the contrary, you think the chicken has an innate idea of doing this; that is to say, that it can think of this, but has no faculty of thinking anything else. The chicken you say pecks by instinct. But if you are going to think every poor chicken endowed with an innate tendency toward a positive truth, why should you think that to man alone this gift is denied? If you carefully consider with an unbiased mind all the circumstances of the early history of science and all the other facts bearing on the question, which are far too various to be specifically alluded to in this lecture, I am quite sure that you must be brought to acknowledge that man's mind has a natural adaptation to imagining correct theories of some kinds, and in particular to correct theories about forces, without some glimmer of which he could not form social ties and consequently could not reproduce his kind. In short, the instincts conducive to assimilation of food, and the instincts conducive to reproduction, must have involved from the beginning certain tendencies to think truly about physics, on the one hand, and about psychics, on the other. It is somehow more than a mere figure of speech to say that nature fecundates the mind of man with ideas which, when those ideas grow up, will resemble their father, Nature. (Peirce, 1903–04, CP 5.591)

Nicholas Rescher mentions rightly that "Peirce puts his finger upon exactly the right point: an evolutionary model of random trial and error with respect to possible hypotheses just cannot operate adequately within the actual (or perhaps even any possible) timespan" (Rescher, 1995, p. 321; cf. Peirce, 1903a, CP 172-173, and Peirce, 1905b, CP 5.431). With these words he summarized a lot of Peirce quotes concerning this point as well as his critique of Popper's model of the growth of scientific knowledge that appears

to him as "crucially deficient" and counterintuitive in that it neglects the possibility of deciding rationally which hypothesis from a set of possible hypotheses should be tested.

Quine mentioned the same point in his discussion of the induction problem, and his solution is, like Peirce's, a "naturalistic" one: "Creatures inveterately wrong in their inductions have a pathetic but praiseworthy tendency to die before reproducing their kind" (Quine, 1969, p. 126). Quine, however, formulates an important restriction: As fundamental as our every day inductions are to our thinking – based on our natural "sense of similarity" and our sorting of things in "natural kinds" – as irrelevant they are "to anything in logic and mathematics" (p. 125). For Quine, it is "a mark of maturity of a branch of science that the notion of similarity or kind finally dissolves, so far as it is relevant to that branch of science. That is, it ultimately submits to analysis in the special terms of that branch of science and logic" (p. 121).

Peirce likewise neglected the relevance of instincts in mathematics (Peirce, 1903a, CP 5.174). In his Carnegie application, he formulates a difference between "scientific reasoning" and "the reasoning of practical men about every day affairs" that sounds very Quinean:

These two would be shown to be governed by somewhat different principles, inasmuch as the practical reasoning is forced to reach some definite conclusion promptly, while science can wait a century or five centuries, if need be, before coming to any conclusion at all. Another cause which acts still more strongly to differentiate the methodeutic of theoretical and practical reasoning is that the latter can be regulated by instinct acting in its natural way, while theory of how one should reason depends upon one's ultimate purpose and is modified with every modification of ethics. Theory is thus at a special disadvantage here; but instinct within its proper domain is generally far keener, surer, and above all swifter, than any deduction from theory can be. Besides, logical instinct has, at all events, to be employed in applying the theory. On the other hand, the ultimate purpose of pure science, as such, is perfectly definite and simple; the theory of purely scientific reasoning can be worked out with mathematical certainty; and the application of the theory does not require the logical instinct to be strained beyond its natural function. On the other hand, if we attempt to apply natural logical instinct to purely scientific questions of any difficulty, it not only becomes uncertain, but if it is heeded, the voice of instinct itself is that objective considerations should be the decisive ones. (Peirce, 1902a, http://www.door.net/arisbe/menu/library/bycsp/L75/Ver2/DRAFTA/DRAFTA.HTM)

The notion of "instinct" is, like the more or less psychological speculation about "ideas" in perception, a rather metaphorical manner of speaking. We may understand the meaning of the assertions, but a scrupulous interpretation finds itself confronted with a kind of "black box." Thus, the plan of Rescher to replace the Peircean "somewhat mysterious capacity of *insight* or *instinct*" by a "*methodology* of inquiry" (Rescher, 1995, pp. 321ff.) seems at first glance be more interesting than guessing what kinds of scientific discoveries might be supported in which way by "instincts," and which not.

Peirce himself offered, in his *Lectures on Pragmatism*, a methodological approach in order to explain the possibility of abductive reasoning. In this way, at least, I would interpret his example of a physicist who "comes across some new phenomenon in his laboratory":

How does he know but the conjunctions of the planets have something to do with it or that it is not perhaps because the dowager empress of China has at that same time a year ago chanced to pronounce some word of mystical power or some invisible jinnee may be present. Think of what trillions of trillions of hypotheses might be made of which one only is true; and yet after two or three or at the very most a dozen guesses, the physicist hits pretty nearly on the correct hypothesis. (Peirce, 1903a, CP 5.172)

The notion of "instincts" seems not to be very helpful here. Contrarily, *in the context of modern science*, many hypotheses are obviously impossible in the physicist's situation. Peirce himself, some paragraphs later, defines the problem of abduction as the problem of "the admissibility of hypotheses to rank as hypotheses" (Peirce, 1903a, CP 5.196). It seems to be more adequate to measure the admissibility of hypotheses with regard to such contexts – i.e. by scientific standards and methods – than by instincts.

Such a methodological approach, however, has to be criticized at a certain point: On the one hand, if we ask how a search-guiding methodology can be developed and legitimized, we fall into the circle that a search-guiding methodology in itself can only be found by a search that must be guided by a methodology of higher level, etc. *ad infinitum*. Thus, it is necessary to discuss the problem of infinite regress. On the other hand, it seems to be evident that the adequacy of a method can only be confirmed or disconfirmed by

application. Regarding the infinite regress mentioned above that seems to imply that an end of the regress is reached when a methodology disturbs our "fitness" for survival. In other words, if our methods of reasoning limit the range of admissible hypotheses, and if the development of these methods in itself is limited by further contexts, etc., then it seems to be plausible that our natural environment is something like an ultimate determining context. If we understand nature as a kind of "ultimate" context in a hierarchy of contexts, then we get something like Peirce's concept of instinct. For he defines the aim of instinctive "reasoning-power" by its conduction "to the probable perpetuation" of a race (Peirce, 1913, EP II, pp. 464f.).

Peirce emphasized a "naturalistic" point of view when he based the possibility and success of abductive reasoning in a certain relationship of mutual dependence to a given world. A methodological approach to this problem should be commensurable with this view. Both could be generalized in the concept of "context" as condition of the possibility of abduction. This concept, however, seems not to be elaborated in Peirce's writings.

ACKNOWLEDGEMENTS

NOTES

1. From Landesinstitut (1994, p. 59ff.). I thank Rolf Biehler for providing this material.
2. Hintikka, 1997c, p. 16, quoting Peirce, 1903b, CP 4.424. Hintikka notes rightly that Peirce in the quoted passage and others verbally neglected the description of his logic as a form of "calculus." As becomes clear, however, from the definition of "exact logic" in Peirce and Ladd-Franklin, 1901–2/1911, CP 3.618, Peirce refers to another understanding of the term.
3. Cf. Peirce, 1903c, CP 4.396; Peirce, 1897, CP 4.172; Peirce, 1908a, CP 4.561n; Peirce, 1902–3, CP 6.351 f.
4. Peirce himself referred to his development of thinking about abduction in a letter as follows ("Abduction" is called "Hypothesis" here): "In various

publications, I gradually made my doctrine more definite, until in 1883 I gave an account of it in *Studies in Logic by Members of the Johns Hopkins University*. The theory there given seems to me substantially correct as far as Induction goes. Later, I was led to see objections to the method in which I there dealt with Hypothesis, in regard to which I had departed from my earlier opinions; and in order to meet these objections, I at first proposed slightly to modify my theory both of Induction and of Hypothesis, leaving my later opinions about their relations to one another, as they were. But this new view on further consideration was found not to be acceptable in regard to Induction; and finally some five years ago I made an entirely fresh investigation, more careful than ever, the result of which was that I return to my early views of the relations of induction and hypothesis, leave the theory of induction as I had it in 1883 substantially, and restrict the modifications of it to hypothesis only" (Peirce, 1901a, L 409: ISP 73; cf. Peirce, 1903a, HLP 282).

5. "Uberty" is one of Peirce's quaintly archaic terms and stands for "fertility" or "productiveness", cf. Peirce, 1913. I thank Guenter Seib for the hint that a "uberous cow" is one giving lots of milk.

6. As a paradigmatic example of scientific abduction Peirce often mentioned Kepler's discovery of the elliptic orbit of Mars; cf. in detail Richter, 1995, pp. 83–93. Kleiner, 1983, criticized Peirce's and N.R. Hanson's interpretation of Kepler's discovery as an example of abductive reasoning.

7. Cf. for the various points for instance Peirce, 1897, CP 4.172; Peirce, 1896, ca., CP 1.420, 434; Peirce, 1908d, CP 7.535n6.

8. Peirce, 1903a, CP 5.181. Cf. also Peirce, 1907, ca., CP 7.36 f., Kelle, 1994, p. 150, and Anderson, 1986, p. 47: "we put old ideas together in a new way and this reorganization itself constitutes a new idea". In a similar manner, Tursman, 1987, p. 19ff. emphasized the "presence of appropriate ideas" in the "neighborhood" as a precondition of abduction, but he confused this interpretation by claiming that "colligation of ideas" would be part of an "inference" to a new scientific idea.

9. Peirce, 1902a, MS L 75: 286, quoted according to Kapitan, 1990, p. 508.

10. "Retroduction" is a further Peircean term for "abduction." I thank André De Tienne from the Peirce Edition Project, Indianapolis, who helped me to obtain this passage from Peirce, 1907b, MS 754 ISP 8, which is not contained in the Microfilm edition.

11. Many of Peirce's statements concerning the instinctive "power of guessing rightly" are quoted by Rescher, 1995. Cf. also Fann, 1970, pp. 35–38. For the relevance of this approach for Chomsky's theory of language learning cf. Wirth, 1993.

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