

Abduction: The Logic of Creativity

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Introduction

C.S. Peirce made relevant contributions in very different fields, but he was primarily interested in the logic of science, and more especially in what he called ‘abduction’ – as opposed to deduction and induction – which is the process whereby hypotheses are generated in order to explain surprising facts (Nubiola 2005). Although there are stirrings of it in Aristotle’s notion of *apagoge*, the modern idea of abduction comes from Peirce (Woods 2017: 137). In fact, Peirce considered abduction to be at the heart not only of scientific research, but also of all ordinary human activities, and in particular artistic creativity (Barrena 2015).

In this chapter, first, the nature of abduction will be explained, providing several key textual sources from Peirce’s manuscripts. Second, scientific and artistic creativity will be described in some detail, highlighting that imagination, which plays a central role in abduction, is at the heart of reasoning. Finally, a number of contemporary applications of abduction from the philosophy of science, artificial intelligence and logic will be mentioned. We point out the richness of Peirce’s conception of abduction that far surpasses the contemporary accounts of creativity.

The classification of arguments

Since the time of his early works in logic, Peirce had been interested in the classification of arguments (W2: 23–48, 1867), in particular the several modes of inference, that is, of the different ways in which a true conclusion follows necessarily or probably from two premises. In 1878, in the series *Illustrations of the Logic of Science*, Peirce published in *Popular Science Monthly* his paper

‘Deduction, Induction and Hypothesis’, which contains a classic exposition of the three modes of inference. According to Peirce, all deduction is nothing more than the application of a rule to a case in order to state a result:

The so-called major premise lays down this rule; as, for example, *All men are mortal*. The other or minor premise states a case under the rule; as, *Enoch was a man*. The conclusion applies the rule to the case and states the result: *Enoch is mortal*. All deduction is of this character; it is merely the application of general rules to particular cases.

CP 2.620; W3: 324, 1878

Not all forms of reasoning are reducible to deduction and can be expressed by a syllogism of this type. Moreover, inductive reasoning never can be reduced to this form, because it is ‘something more than the mere application of a general rule to a particular case’ (CP 2.620; W3: 324, 1878). In order to illustrate the contrast between the different kinds of reasoning, Peirce employs the well-known example of the bag of beans, which has not always been well explained and well understood (CP 2.621–623; W3: 324–326, 1878):

Let us imagine that we enter a room in which there are several bags of beans. If, from a bag of beans (of which we know that all are white), we take a handful, we can assert before looking at them that the handful of beans is white (if the rule is true). This has been a necessary deduction, the application of a rule to a case to state a result. We have, in effect, the following syllogism:

Rule: All the beans from this bag are white.
Case: These beans are from this bag.
Result: These beans are white.

Let us imagine now that without knowing the colour of the beans of the bag, we take a handful at random and, finding that all of the beans in the handful are white, we conclude that all the beans in the bag are white. The induction then is the inference of the rule from the case and result:

Case: These beans are from this bag.
Result: These beans are white.
Rule: All the beans from this bag are white.

In this case the inference is not necessary and it is an inversion of the deductive syllogism. Deductive reasoning is analytic, since the conclusion does not add anything to what it is already in the premises. On the contrary, the inductive reasoning is synthetic or ampliative, since what is asserted in the conclusion was not in the premises.

But there is a second way of inverting a deductive syllogism to produce a synthetic inference. Let us suppose a new situation in which we enter in a room in which there are a number of bags, containing different kinds of beans. We find on the table a handful of white beans, and after some searching we find that one of the bags contains white beans only. Then we infer – ‘as a probability, or as a fair guess’ – that very likely the handful on the table was taken out of that bag. ‘This sort of inference is called making *an hypothesis*. It is the inference of a *case* from a *rule* and *result*’ (CP 2.623; W3: 325, 1878):

Rule: All the beans from this bag are white.

Result: These beans are white.

Case: These beans are from this bag.

In this paper, Peirce does not use still the term ‘abduction’ for this kind of inference. He uses the terms ‘hypothesis’, ‘a fair guess’ or ‘supposition’. As in the case of induction, this hypothetical inference is not necessary, but merely probable and is also a kind of ampliative or synthetic reasoning. Hypotheses may be very diverse, but all of them have in common that they are formulated to explain an observed phenomenon. Peirce illustrates his exposition with examples from natural science (from the presence of marine fossils in the interior of the country we infer that the sea once was upon this land) and from the human sciences (from the documents that refer to Napoleon Bonaparte we infer that he really existed), and with a very appealing personal experience that deserves quotation:

I once landed at a seaport in a Turkish province; and, as I was walking up to the house which I was to visit, I met a man upon horseback, surrounded by four horsemen holding a canopy over his head. As the governor of the province was the only personage I could think of who would be so greatly honored, I inferred that this was he. This was an hypothesis.

CP 2.625; W3: 326, 1878

The consideration of abduction as inference, however, suffered an evolution over the years that must be taken into account for the correct understanding of this notion. Kuang Thi Fann argued, in a widely quoted study, that there were two distinct periods in the history of this concept. Peirce called it ‘hypothesis’ at the beginning, while later he gave it the name of ‘abduction’ or ‘retroduction’. Between the two periods, separated approximately by the turn of the century, there is a fundamental evolution: Peirce goes from considering deduction, induction and hypothesis as three types of inference to consider them as stages of a single process of research. This change is not a contradiction, but an expanded way of

considering the forms of inference in a new direction, an evolution that can only be seen to the light of the first period (Fann 1970: 10).

Peirce speaks in that second period of three kinds of arguments (CP 2.96, c. 1902) or reasoning (CP 5.145, 1903; 5.161, 1903). He carries out an extension of the concept of inference to that of reasoning to include the methodological function. Inferences are considered, in addition to mental actions, as parts of a methodological process, as interdependent and intertwined stages of the scientific method of research. The three types of inference will then appear as steps of a single process aimed at the discovery of truth and the advance of rational investigation.

In this second period, the generalizations or empirical laws from particular cases are obtained also by abduction, while induction simply confirms or denies: as we will see below it is the conclusive step of investigation. Although Peirce differentiated them from the beginning, he himself considered that the distinction of abduction and induction he had made as different forms of inference was not enough, and Peirce affirmed that he had confused induction with hypotheses in some aspects. He explains it this way around 1902:

Upon this subject, my doctrine has been immensely improved since my essay 'A Theory of Probable Inference' was published in 1883. In what I there said about 'Hypothetic Inference' I was an explorer upon untrodden ground. I committed, though I half corrected, a slight positive error, which is easily set right without essentially altering my position. But my capital error was a negative one, in not perceiving that, according to my own principles, the reasoning with which I was there dealing could not be the reasoning by which we are led to adopt a hypothesis, although I all but stated as much. But I was too much taken up in considering syllogistic forms and the doctrine of logical extension and comprehension, both of which I made more fundamental than they really are. As long as I held that opinion, my conceptions of Abduction necessarily confused two different kinds of reasoning.

CP 2.102, c. 1902

In the second period, when Peirce talks about stages within scientific methodology, abduction is clarified and defined as the only type of synthetic reasoning (CP 2.777, 1901). It is one thing to discover, to create, to imagine hypotheses and another to justify, to affirm or to deny them. The latter would be the role of induction. Abduction was then the only logical operation that could explain the appearance of new conceptions. We will see below what Peirce properly understands by abduction.

The nature of abduction

For Peirce, 'not the smallest advance can be made in knowledge beyond the stage of vacant staring, without making an abduction at every step' (R692, 27, 1901). Peirce attributes the emergence of the first insight, in which the whole force of the discovery is already contained, to abduction, which 'consists in examining a mass of facts and in allowing these facts to suggest a theory' (CP 8.209, 1905). Peirce refers on other occasions to abduction as 'the only logical operation which introduces any new idea' (CP 5.171, 1903). It is, according to Peirce, a synthesis of the highest kind, that which the mind is compelled to make not by the inward attractions of the feelings, nor by a transcendental force of necessity, but in the interest of intelligibility. Abduction is

that process in which the mind goes over all the facts [of] the case, absorbs them, digests them, sleeps over them, assimilates them, dreams of them, and finally is prompted to deliver them in a form, which, if it adds something to them, does so only because the addition serves to render intelligible what without it, is unintelligible.

R857: 4–5, n.d.

That synthesis is done by introducing an idea not contained in the data, which gives them connections which they would not otherwise have had (CP 1.383, c. 1890).

Abduction is a kind of inference characterized by probability. The conclusion reached by abduction is conjectural, thus only probable. Abduction is considered by Peirce as the weakest and most insecure type of reasoning; its *uberty* is high, but the security is low (CP 8.385–388, 1913). It is an extremely fallible reasoning:

The abductive suggestion comes to us like a flash. It is an act of *insight*, although of extremely fallible 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 5.181, 1903

However, the hypothesis that arises, although fallible, can be proved or embodied in a theory or in a work of art, and that is what differentiates it, as Santaella has written, from mental confusions, delusions, sterile daydreams and frivolous games (Santaella 1991: 127).

In his later years Peirce dedicated a lot of writings – a good amount of them still unpublished – to the study of this operation. The study of abduction became

so important for Peirce that he did not hesitate to write that the question of pragmatism ‘is nothing else than the question of the logic of abduction’ (CP 5.196, 1903).

According to Peirce,

Abduction is that kind of operation which suggests a statement in no wise contained in the data from which it sets out. There is a more familiar name for it than *abduction*; for it is neither more nor less than guessing. A given object presents an extraordinary combination of characters of which we should like to have an explanation. That there is any explanation of them is a pure assumption; and if there be, it is some one hidden fact which explains them; while there are, perhaps, a million other possible ways of explaining them, if they were not all, unfortunately, false. A man is found in the streets of New York stabbed in the back. The chief of police might open a directory and put his finger on any name and guess that that is the name of the murderer. How much would such a guess be worth? But the number of names in the directory does not approach the multitude of possible laws of attraction which would have accounted for Kepler’s [*sic*] laws of planetary motion and in advance of verification by predictions of perturbations etc., would have accounted for them to perfection. Newton, you will say, assumed that the law would be a simple one. But what was that but piling guess on guess? Surely, vastly more phenomena in nature are complex than simple. By its very definition abduction leads to a hypothesis which is entirely foreign to the data. To assert the truth of its conclusion ever so dubiously would be too much. There is no warrant for doing more than putting it as an interrogation. To do that would seem to be innocent; yet if the interrogation means anything, it means that the hypothesis is to be tested.

R692: 24; 23–25, 1901

We are now in a better position to understand clearly that abduction has a logical form and it is inserted in the domain of thirdness. It is a form of reasoning and, as such, it is possible a rational control over it, because *inference* is always essentially deliberate, and self-controlled (CP 5.108, 1903), although that control is sometimes weak and there is no force in the reasoning (CP 8.209, c. 1905). If rational control over abduction were not possible, it would not make sense to give it value. According to Peirce’s explanation in the seventh of his ‘*Lectures on Pragmatism*’, the logic structure of abduction is the following (CP 5.189, 1903):

The surprising fact, C, is observed;
But if A were true, C would be a matter of course,
Hence, there is reason to suspect that A is true.

This is the logical structure of all abductions. The key for understanding it properly is to realize that the trigger of abduction is the surprising character of the fact referred to in the first premise, and the ‘motor’ the work of imagination in the second premise. In the second premise, one discovers that if some hypothesis were true it would render the surprising fact to be a matter of course, something normal, reasonable, and thus something not surprising. If this is the case it is reasonable to think that A is true. Not only detective stories are full of abductive reasoning, but our everyday lives contain many examples of its effective use. Medical diagnoses, for instance, follow its structure: from certain surprising symptoms and a classification of diseases, some particular disease is chosen to make those symptoms reasonable (Eco and Sebeok 1983; Niño 2001).

Generating new ideas: the role of surprise and rational instinct

But, how does the right new idea spring? Peirce was deeply impressed by the phenomenon of the introduction of new ideas in scientific research, which is totally unexplained by a mere calculation of probabilities.

Research always starts with the acknowledgment of some anomaly, of something surprising. But what makes a phenomenon surprising? It is not mere irregularity. ‘Nobody is surprised that the trees in a forest do not form a regular pattern, or asks for any explanation of such a fact. So, irregularity does not prompt us to ask for an explanation’ (CP 7.189, 1901). Mere irregularity creates no surprise where no definite regularity is expected, because in our life irregularity is ‘the overwhelmingly preponderant rule of experience, and regularity only the strange exception’ (CP 7.189, 1901).

In what a state of amazement should I pass my life, if I were to wonder why there was no regularity connecting days upon which I receive an even number of letters by mail and nights on which I notice an even number of shooting stars!
But who would seek explanations for irregularities like that?

CP 7.189, 1901

An event that can be answered in a habitual form does not cause any surprise. On the contrary, a *surprising* fact requires a change in our rational habit of belief; it demands an explanation. An explanation makes the fact rational, that is, it enables the acquisition of a belief that explains the fact, rendering it reasonable. When the phenomenon is reasonable it is no longer surprising. In Peirce’s words:

What an explanation of a phenomenon does is to supply a proposition which, if it had been known to be true before the phenomenon presented itself, would have rendered that phenomenon predictable, if not with certainty, at least as something very likely to occur. It thus renders that phenomenon rational, –that is, makes it a logical consequence, necessary or probable.

CP 7.192, 1901

The phenomenon of surprise has no relation to Cartesian doubt, which for Peirce is a mere ‘paper-doubt’ (CP 5.445, 1905; 5.416, 1905). Genuine doubt always has an external origin, usually from surprise, and cannot be produced by an act of the will (CP 5.443, 1905). ‘There is every reason to suppose that belief came first, and the power of doubting long after. Doubt, usually, perhaps always, takes its rise from surprise, which supposes previous belief; and surprises come with novel environment’ (CP 5.512, 1905). Surprise produces some irritation and demands a hypothesis; it forces us to seek an abduction which turns the surprising phenomenon into a reasonable one.

In that search for explanations, a remarkable feature of scientific investigation is that it can reach a true explanation after a relatively small number of attempts (Génova 1997: 68). This is illustrated by Peirce in the sixth of his ‘*Lectures on Pragmatism*’ (1903):

A man must be downright crazy to deny that science has made many true discoveries. But every single item of scientific theory which stands established today has been due to Abduction.

But how is it that all this truth has ever been lit up by a process in which there is no compulsiveness nor tendency toward compulsiveness? Is it by chance? Consider the multitude of theories that might have been suggested. A physicist 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. By chance he would not have been likely to do so in the whole time that has elapsed since the earth was solidified.

CP 5.172, 1903

This is the question that lies at the foundation of all the scientific enterprise: Why we get theories right and why we do it in a relatively easy way? For Peirce, the explanation of this surprising phenomenon of the human ability to choose easily

and correctly between those innumerable hypotheses lies in ‘that man’s mind must have been attuned to the truth of things in order to discover what he has discovered. It is the very bedrock of logical truth’ (CP 6.476, 1908). Peirce appeals in his ‘A Neglected Argument for the Reality of God’ (CP 6.452–485, 1908) and in several other places (CP 1.80, c. 1896; 1.630, 1898; 5.589, 1898, 6.10, 1891; 6.567, 1905) to *il lume naturale* – borrowing the expression from Galileo – in order to explain this surprising ability to guess the right answer from a great variety of possibilities. It is:

The simpler Hypothesis in the sense of the more facile and natural, the one that instinct suggests, that must be preferred; for the reason that, unless man have a natural bent in accordance with nature’s, he has no chance of understanding nature at all.

CP 6.477, 1908

In Peirce’s mature thought this plausibility, this intuitive force of abduction, is where its validity resides: ‘probability proper had nothing to do with the validity of Abduction, unless in a doubly indirect manner’ (CP 2.102, 1903). When Peirce raises the question of the validity of this type of reasoning he asserts:

All the ideas of science come to it by the way of Abduction. Abduction consists in studying facts and devising a theory to explain them. Its only justification is that if we are ever to understand things at all, it must be in that way.

CP 5.145, 1903

On another occasion Peirce also writes: ‘if there be any attainable truth . . . it is plain that the only way in which it is to be attained is by trying the hypotheses which seem reasonable and which lead to such consequences as are observed’ (CP 2.776, 1901). Peirce considers that this argument is far from being a logical justification for its validity and affirms: ‘It is more to the purpose, however, to urge that the strength of the impulse is a symptom of its being instinctive’ (CP 6.476, 1908). That is, in the end, abduction depends for its validity on instinct, ‘it is really an appeal to instinct’ (CP 1.630, 1898), although that does not mean that it is irrational. If that instinct did not exist, it would be impossible to explain knowledge (CP 5.603, 1903; 2.753, 1883).

This ability of guessing right is neither blind nor infallible, but is an *instinctive* ability, similar to the animal instinct of flying or nest-building of ordinary birds. Instinct allows humans to survive, and also allows them to raise far above the general level of their intelligence in those performances that are their proper function: to embody general ideas in art creations, in utilities, and above all in theoretical cognition (CP 6.476, 1908). That spontaneous ability to guess is

therefore an instinct comparable to that of animals. The ability to abduct the proper hypothesis is for Peirce the distinctive and highest human instinct:

This Faculty is at the same time of the general nature of Instinct, resembling the instincts of the animals in its so far surpassing the general powers of our reason and for its directing us as if we were in possession of facts that are entirely beyond the reach of our senses. It resembles instinct too in its small liability to error; for though it goes wrong oftener than right, yet the relative frequency with which it is right is on the whole the most wonderful thing in our constitution.

CP 5.173, 1903

Since abduction is a kind of instinctive and rational inference at the same time, Ayim has suggested calling this ability the *rational instinct*. This guessing instinct is a result of the development of our animal instincts and of the process of rational adaptation to our environment (Ayim 1974: 42). It could be also called *creativity*.

However, that natural light that sustains abduction is a peculiar instinct, because it requires to be put to test. *Il lume naturale* would not serve for the effective advancement of knowledge, even if it justifies it, without further proof, since abduction is, as has already been said, fallible: ‘we are driven oftentimes in science to try the suggestions of instinct; but we only *try* them, we compare them with experience, we hold ourselves ready to throw them overboard at a moment’s notice from experience’ (CP 1.634, 1898). In this sense Ayim affirmed that, for Peirce, the operation of *il lume naturale* marks the first and indispensable step of all scientific advance. But unless based on cold and solid observations and scientific experiments, intuition has no more relevance than that of a common reverie (Ayim 1974: 57). Proof is required, and therefore abduction must be continued by the next steps of scientific method.

Scientific creativity

For Peirce, science is a strongly creative activity aimed at discovering the truth. The peculiar application of the scientific methodology allows us to face reality in a creative way and to build explanations to understand it: ‘That which constitutes science, then, is not so much correct conclusions, as it is a correct method’ (CP 6.428, 1893), holds Peirce.

The phenomenon of scientific creativity involves the combination of abduction, deduction and induction. The Peircean scientific methodology includes a

process with abductive, deductive and inductive moments, in which the conclusions of one investigation become new starting points for further investigations.

To abduction corresponds the task of introducing new ideas in science; in a word, creativity. Deduction draws the necessary and verifiable conclusions that *should follow* if the hypothesis would be true, and induction confirms experimentally the hypothesis in a certain number of cases. They are three kinds of reasoning that do not occur independently or in parallel, but integrated and cooperating in the successive steps of the scientific method.

Génova 1997: 56–57

The starting point of that process of research is always abduction. Peirce describes as follows that first stage of inquiry:

The whole series of mental performances between the notice of the wonderful phenomenon and the acceptance of the hypothesis, during which the usually docile understanding seems to hold the bit between its teeth and to have us at its mercy, the search for pertinent circumstances and the laying hold of them, sometimes without our cognizance, the scrutiny of them, the dark laboring, the bursting out of the startling conjecture, the remarking of its smooth fitting to the anomaly, as it is turned back and forth like a key in a lock, and the final estimation of its Plausibility, I reckon as composing the First Stage of Inquiry.

CP 6.469, 1908

Abduction generates the hypothesis that suggests what experiments must be performed, in which directions it is necessary to look. The scientist, without a previous hypothesis, cannot determine what experiments are necessary for further research. For this reason, it is striking that most of the contemporary philosophers of science who analyse the scientific method tend to ignore completely the logical problem of the source of hypotheses or scientific theories (Génova 1997: 117; Hanson 1961: 20). For them, scientific method starts when a theory is available to be confirmed or refuted by experiments; the origin of the new ideas is considered an issue belonging to psychology or the sociology of knowledge. The origin of hypothesis is regarded as a question totally alien to logic; it is considered, in Peirce's term, 'a sort of logical supernumerary' (R692 26, 1901).

Peirce, however, explains through abduction the emergence of a hypothesis that is provisionally adopted until it is proved. For that, it must be first explained and clarified through deduction: 'the first thing that will be done, as soon as a hypothesis has been adopted, will be to trace out its necessary and probable

experiential consequences. This step is *deduction*' (CP 7.203, 1901). Hypotheses are subject to the law of growth and they tend to be more and more defined (CP 6.466, 1908). When explained by deduction, the idea becomes a more precise one. Then, those consequences that have been deduced must be experimentally proved through induction: they must be capable of experimental verification (CP 5.197, 1903). It is the moment of making experiments and comparing those predictions with the actual results of the experiments (CP 7.206, 1901). Induction is the operation that induces an assent, this assent or modified assent being regarded as a provisional result (CP 5.590, 1903), for the achievements of science can always be improved or refuted in the future. But only after induction can a significant value be attached to the creative hypothesis.

In summary, science consists in a process in which abduction merely suggests that something *may be*; deduction proves that something *must be*; and induction shows that something *actually is* operative (CP 5.171, 1903). Creativity goes beyond the invention of the hypothesis and extends throughout the whole method. The success of science is not a stroke of luck, but depends on continued work. It is not a cluster of brilliant intuitions, but a process, and imagination is fundamental for the development of this process. Without imagination it is not possible to do science. As Peirce writes:

When a man desires ardently to know the truth, his first effort will be to imagine what that truth can be. He cannot prosecute his pursuit long without finding that imagination unbridled is sure to carry him off the track. Yet nevertheless, it remains true that there is, after all, nothing but imagination that can ever supply him an inkling of the truth. He can stare stupidly at phenomena; but in the absence of imagination they will not connect themselves together in any rational way.

CP 1.46, c. 1896

Imagination, essential for abduction, allows us to explain reality and to unravel its laws. Thus, abduction makes it clear that there are other dimensions intermingled with reason; otherwise the hypothesis could not arise. In the search for an explanation the understanding seems to run wild. The ability to take a leap would not be explained without the key involvement of the imagination. In 1893, Peirce defended the need for the imaginative capacity:

People who build castles in the air do not, for the most part, accomplish much, it is true; but every man who does accomplish great things is given to building elaborate castles in the air and then painfully copying them on solid ground. Indeed, the whole business of ratiocination, and all that makes us intellectual

beings, is performed in imagination . . . Mere imagination would indeed be mere trifling; only no imagination is *mere*.

CP 6.286, 1893

Imagination is therefore necessary for abduction and for the development of science. 'It is not too much to say' – Peirce states – 'that next after the passion to learn there is no quality so indispensable to the successful prosecution of science as imagination' (CP 1.47, c. 1896). The investigation advances by weighing the value of the observed, and imagining possible explanations until something that appears to us as plausible arises. Abduction involves the development of ideas in the imagination: 'its theatre, Peirce writes, is the plastic inner world' (R318:44, c. 1907). 'The scientific imagination dreams of explanations and laws' (CP 1.48, c. 1896).

Reason, as abduction shows us, is essentially creative. In the context of his pragmatism, Peirce writes:

What he adores, if he is a good pragmatist, is *power*; not the sham power of brute force, which, even in its own specialty of spoiling things, secures such slight results; but the creative power of reasonableness, which subdues all other powers, and rules over them with its sceptre, knowledge, and its globe, love.

CP 5.520, c. 1905

Artistic creativity

Although it may seem that Peirce's interests were far removed from aesthetics and art, his philosophy, as Hans Joas has pointed out, was determined to find a place for artistic creativity in an era characterized by the domination of science (Joas 1998: 5).

What Peirce pointed out about scientific creativity applies also to art. There is an artistic abduction by which relationships that had never before been established are obtained. In that sense, as Peirce affirms, the poet's or the novelist's work is not so different from that of the scientist:

The work of the poet or novelist is not so utterly different from that of the scientific man. The artist introduces a fiction; but it is not an arbitrary one; it exhibits affinities to which the mind accords a certain approval in pronouncing them beautiful, which if it is not exactly the same as saying that the synthesis is true, is something of the same general kind.

CP 1.383, 1887

Artistic abduction must start – like any other – from experience. The artist will be precisely the one who sees things as they appear. Artists, Peirce holds, are much finer and more accurate observers than scientists are, except of the special minutiae that the scientific man is looking for (CP 1.315, 1903). The ability to observe the world in an aesthetic way, to discern the world without judging it, is not something that is done just like that, but requires discipline and training. The artist is the one who has that preparation, who is able to recognize sensations with accuracy, rigour and depth. Peirce describes that extraordinary capacity for perception in the following way:

When the ground is covered by snow on which the sun shines brightly except where shadows fall, if you ask any ordinary man what its color appears to be, he will tell you white, pure white, whiter in the sunlight, a little greyish in the shadow. But that is not what is before his eyes that he is describing; it is his theory of what *ought* to be seen. The artist will tell him that the shadows are not grey but a dull blue and that the snow in the sunshine is of a rich yellow. That artist's observational power is what is most wanted in the study of phenomenology.

CP 5.42, 1903

Therefore, the artistic abduction begins, like the scientific one, with a surprising fact, which in the case of art is perhaps a state of restlessness, a feeling that in some sense the world is not felt as it should be. The artist then tries to fill that void of experience. That which the artist perceives will be expressed in a thirdness, in something original and intelligible that can be interpreted by others. This Peircean idea of art as expression means that the variety of experience and human sensations, albeit diverse and ungraspable, is also rationalizable, because the artist manages to express feelings by giving them shape and embodying them in a third. The artist deals with feelings that are possibilities; she perceives the world in its being present, in its firstness, and plays with the imagination giving rise to a thirdness that allows to express in some way that firstness. Art is creation, discovery of a way to embody reasonableness; art is to find a way to express that which cannot be expressed, to communicate a feeling that is internal by giving it a reasonable form and making it external.

The hypothesis that arises through artistic abduction is nevertheless only one of the possible ways in which that quality could be embodied, and it is only a first idea that must be worked on until it acquires its definitive form. Douglas Anderson developed in his book *Creativity and the Philosophy of C. S. Peirce* (Anderson 1987) an analogy between scientific and artistic creativity. Anderson considers that abduction in art, as in science, is followed by a phase of deduction

and another of induction. It is necessary to explain and 'prove' the artistic hypothesis, which otherwise would be reduced to mere emotion. Abduction is only the starting point of a process in which the artist loves her idea and lets it develop, allowing it to suggest its own perfection.

Based on that first hypothesis, the artist in the first place projects what the work of art will be like. Through deduction, the creative idea becomes an existing work of art; it becomes a likeness, a model that can be tested by contemplating it, for example by making a first design, as Peirce explains:

Another example of the use of a likeness is the design an artist draws of a statue, pictorial composition, architectural elevation, or piece of decoration, by the contemplation of which he can ascertain whether what he proposes will be beautiful and satisfactory.

CP 2.281, 1893

As in science, artistic abduction is not infallible. Many times the artist will reject her first idea as it begins to take shape and she realizes that it does not meet her expectations. The deductive phase of art does not consist in predicting consequences as in science, but in eliminating possibilities that do not satisfy the aim of the artist. In this sense, the creative process of the artist – although different in other aspects – is very similar to that of the scientist, since it requires experimentation.

After abduction, subsequent phases involve self-critical corrections and the elimination of errors that are part of the creative process itself. Many times the plan of the artist is modified in the very execution of the work, in the materialization of the idea. In the inductive phase, the truth of the hypothesis that deduction has materialized is verified. There is a feedback between the ideal plan and the concrete work that emerges. Through induction the artist has to judge his work. Unlike science, art can only be true with respect to itself, insofar as it fulfils its purpose of creating what is admirable in itself, as aesthetics points out. It is not a matter of seeing if there is correspondence with the facts but of seeing if the work is admirable, if it satisfies its purpose, that is, if it has managed to beautifully express a feeling by making it reasonable. The artist must judge for herself and she also must submit her work, as in science, to the judgment of a community in an indefinite time. In the end the generations do, or do not, approve the works of art. Peirce does not hold an aesthetic subjectivism where anything goes, but the work of art must fulfil its purpose.

The three stages of the Peircean method are intermingled also in art until they give rise to a work that will always be incomplete in some sense. As happens in science, the work of art will always be open to later refutations.

Artistic abduction seeks to capture sensations, restlessness and feelings, while the scientist seeks rational explanations. There is more freedom in artistic abduction. Scientific hypotheses, although they are also creations, can only afford to be original if they explain the facts in question (Anderson 1987: 44). Imagination in science is not entirely free, since hypotheses cannot be released from the hand of reality. Speaking of Kepler's work, Peirce thus distinguished the scientific imagination from the poetic one:

What kind of an imagination is required to form a mental diagram of a complicated state of facts? Not that poet-imagination that 'bodies forth the forms of things unknowne,' but a docile imagination, quick to take the Dame Nature's hints. The poet-imagination riots in ornaments and accessories; a Kepler's [*sic*] makes the clothing and the flesh drop off, and the apparition of the naked skeleton of truth to stand revealed before him.

R1284: 12–13, c. 1892

Science is interested in discovering the truth, in conforming reason to the facts of experience. The artist, on the other hand, seeks to create what is admirable in itself. While scientific reasoning ends with reasonable ideas, art ends with reasonable feelings (Anderson 1897: 60). But both science and art are driven by abduction.

Contemporary applications of abduction

As we have seen, abduction pervades common-sense reasoning, scientific inquiry and artistic creativity. Peirce saw the importance of this way of reasoning and proposed the abductive logic as the motor for the growth of human knowledge; since then, abduction has been applied in areas like the theory of scientific research, artificial intelligence or computational logic. In recent decades, abduction has been extensively studied in logic, semiotics, the philosophy of science, computer science and cognitive science in a desire to recover and extend rationality (Park 2017: 1).

Abduction has attracted a lot of attention in artificial intelligence (A.I.), in areas like programming, knowledge assimilation or diagnosis, and also for databases and knowledge bases. In this context, the general trend interprets abduction as 'backwards deduction plus additional conditions' (Aliseda 2006: 40). Aliseda has pointed out that Peirce's formulation of abduction goes beyond that of a logical argument to become an epistemic process which has given rise

in the field of A.I. to close connections with theories of belief revision (Aliseda 2006: 177). Peirce sustained through abduction an epistemic transition between the states of doubt and belief, and so in A.I. has appeared an 'abductive expansion' and an 'abductive revision' where abduction would apply to the revision of beliefs (Aliseda 2006: 180–184).

In the field of logic, we can highlight the proposal of Gabbay and Woods, who have tried to apply abduction to the practical logic of cognitive systems, and in particular to the resolution of problems by cognitive agents (Gabbay and Woods 2005). Also in this field, Aliseda has proposed semantic tableaux as a natural vehicle for implementing abduction, since they allow for a clear formulation of what counts as an abductive explanation, while being flexible and suggestive as to possible modifications and extensions (Aliseda 2006: 130).

In the field of logic programming, abduction has been used as a form of computing, specifically as a 'repair mechanism' completing a program with the facts needed for a query to succeed (Aliseda 2006: 41); abduction as a control mechanism is different from the blind deduction and it is used to control which outcomes will occur. The work of Kowalski (1979) and Kakas (1995) can be mentioned in this area.

In the field of epistemology, Haig has pointed out that traditionally inductive and hypothetic-deductive methods have been considered, but that in recent years more comprehensive methods have been proposed, methods that begin with phenomena that must be explained and not with theories that have to be analysed (Haig 2005: 371). Thus, theories such as ATOM (Abductive Theory of Method) appear, as Haig calls it, or TEC (Theory of Explanatory Coherence), proposed by Thagard, who determines the coherence of an explanatory theory in terms of three criteria: consilience, simplicity and analogy (Thagard 1988, 1992).

The above are just a small sample of the numerous contemporary applications of abduction. However, it should be noted that abduction has not always been correctly interpreted at least according to the original version of Charles S. Peirce. In many of these applications, abduction has been understood as inference to the best explanation, that is, to the more simple and coherent explanation (Harman 1965; Day & Kincaid 1994; Lipton 2004).

At other times, abduction has been used as a tool for the justification of hypotheses. It must be stressed here that abduction understood in the Peircean sense not only explains the selection of hypotheses, but also their generation. According to Peirce there is a logic of creativity, 'a purely logical doctrine of how discovery must take place' and 'in addition to this, there may be a psychological

account of the matter, of the utmost importance' (CP 2.107, 1892). Abduction is not equivalent to a generalization or to a type of induction, as it has sometimes been confused in some of the contemporary applications. Flach and Kakas, for example, maintain that there are explanatory hypotheses and inductive or generalizing hypotheses (Flach & Kakas 2000), which would be a contradiction in itself, since induction implies for Peirce the acceptance or final refutation of the hypotheses while abduction does not value hypotheses nor can it provide proof of their validity.

In summary, it can be affirmed that although it is remarkable to notice the ubiquity of abduction well beyond the boundary of logic or philosophy, we should also grant that those authors have failed to secure the core meaning of abduction (Park 2017: 1). According to Niño: 'I note that between the features of current abduction and Peirce's abduction – in general – there is a distance similar to that between Dalton's atom and Bohr's, and in that sense, I'm not sure that the developments (uses) around abduction in contemporary fields are developments (in the sense of progress) of Peirce's abduction' (Niño 2007: 348).

Peircean abduction is a kind of inference, but a peculiar inference that would not be possible without instinct and imagination. It has not always been understood and applied in this way; sometimes, it has been forgotten that abduction starts with a surprise and not with the mere analysis of data, that it is a reasoning that goes backwards and that it is verifiable – and must be verified – through deduction and induction. All these elements are present in the Peircean abduction and make it a richer explanation for the modifications in the background theory which explains an amazing fact (Aliseda 2006: 198). That is, Peircean abduction is a much richer and more powerful understanding of human creativity than most of the available current theories: its potential development should be explored in the future with more detail and attention. Peirce's thought is always a trove, but particularly in this issue of creativity.

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