Scientific Inquiry as a Self-correcting Process

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Abstract:

Peirce claims that the methods of abduction, deduction and induction are jointly sufficient for the attainment of truth, regardless of the state of belief from which inquiry begins. This article summarizes Peirce’s defence of the thesis that the scientific method is self-corrective and addresses common mistakes in its interpretation.

Peirce characterizes logic as the art of devising methods of research (CP 7.59). Developing a method of inquiry in logic is not, for Peirce, a matter of codifying scientific practice, for neither the past success of a method nor its pervasiveness among inquirers determines its validity. It is rather a matter of demonstrating on purely logical grounds that pursuit of the method would lead to the truth. Peirce believes that it is too much to hope for a method that precludes all risk of error but all inquiry requires in order to be rational is a method that would eventually lead inquirers to rectify their mistakes. Peirce takes scientific inquiry to be justified not because it is infallible but because it is self-correcting:

> …inquiry of every type, fully carried out, has the vital power of self-correction and of growth. This is a property so deeply saturating its inmost nature that it may truly be said that there is but one thing needful for learning the truth, and that is a hearty and active desire to learn what is true. If you really want to learn the truth, you will, by however devious a path, be surely led into the way of truth, at last. (CP 5.582)

It is tempting to view Peirce’s remarks concerning the capacity of science to correct itself as an expression of unbridled optimism (Laudan [1981]). But the claim that science is self-correcting is no mere article of faith on Peirce’s part. In fact, he views the defence of this claim as essential to his case for the superiority of science over other methods of fixing belief.

It might be thought that Peirce can establish that science is self-correcting simply by appealing to his theory of truth. Once truth is identified with the opinion upon which scientific inquirers would ultimately agree, the capacity of science to arrive at the truth would seem guaranteed as a matter of definition. However, Peirce does not merely tout the slogan that truth is defined in terms of rational inquiry, he attempts to give it content in terms of a robust theory of method and it does not follow from Peirce’s definition of truth that the scientific method as he understands it is destined to succeed.

Before discussing further Peirce’s defence of the scientific method, it is important to explain some of the constraints he imposes on philosophical justifications of science. First and foremost, Peirce insists that it is circular to defend a method by appeal to matters of fact discovered through its use. Discoveries in the natural sciences have no place in establishing a theory of method in logic. Peirce does think logic must draw principles from mathematics but no circularity threatens since mathematics does not presuppose knowledge of fact. As defined by Peirce, mathematics is "the study of the substance of hypotheses with a view to the drawing of necessary conclusions from them" (NEM 3: 41). Since mathematical hypotheses are assumed, not asserted, mathematical theorems are hypothetical and hold independently of the way the world is (CP 1.245). While Peirce rejects the idea that the scientific method can be deduced from first principles, his exclusion of appeals to material facts in logic leads him to hold that principles used in defence of the scientific method must themselves be justified by mathematical reasoning, that is, by deduction.

Peirce takes the scientific method to comprise three subsidiary methods: abduction, deduction and induction. Each of these subsidiary methods involves a form of inference licensing the determination of a conclusion from a set of premises according to a rule or "leading principle". For Peirce, claiming a particular inference is valid implies that it is a correct application of the relevant leading principle and that the leading principle has "one kind of virtue or another in producing truth" (CP 2.780). Since the three forms of inference are irreducible (CP 5.146), each involves a distinct leading principle and each must lead to truth in a distinctive way.[1] The burden of Peirce's defence of the scientific method is to show, first, that each form of inference has "that sort of efficacy in leading to the truth, which it professes to have" (CP 2.779) and, second, that persistent and judicious use of abduction, deduction and induction in concert would lead from any arbitrary state of belief, however erroneous, to knowledge of the truth (CP 7.327). What follows is a summary of Peirce's case for these two claims.

The Validity of Abduction

Peirce holds that inquiry begins when a belief is contradicted by experience. Surprises generate doubts and demands for explanations. Inquirers respond by formulating hypotheses to account for unexpected phenomena. Peirce calls the invention, entertainment and selection of hypotheses "abduction"[2] and he views it as the "First Stage of Inquiry" (CP 6.469).

Peirce doubts there are universal rules for generating novel hypotheses. To that extent there is no fathoming the creative mind. Nevertheless, he insists that the evaluation of hypotheses involves “logical inference… having a perfectly definite logical form” (CP 5.188):

> The surprising fact, *C*, is observed;
>
> But if *A* were true, *C* would be a matter of course,
>
> Hence, there is reason to suspect *A* is true. (CP 5.189)

For example, should 90 out of 100 tosses of a coin come up heads, Peirce thinks it reasonable to infer that the coin is weighted so as to land heads roughly 90% of the time. The conclusion is justified because if it were true, the observed data would not be surprising (CP 6.469). As the only rationale for adopting a hypothesis is that it explains unexpected data, it can never be inferred by abduction that a phenomenon is utterly inexplicable.

The foregoing logical constraints on abductive inference do not suffice to determine the choice of an hypothesis uniquely (CP 7.220). That a coin is unfairly weighted is only one of many possible explanations for its turning up heads 90 times out of 100. The method of tossing might have been biased, the coin tosser might have been engaged in sleight-of-hand or the outcome might have been the result of chance, however improbable that may be. To select a working hypothesis from among those available Peirce applies principles pertaining to the “economy of research” (NEM 4: 38). The goal is to minimize the cost of testing hypotheses while maximizing the informativeness of the results of the tests that are carried out.

Peirce insists that even at its logical best abduction can never be taken to yield more than a guess at the truth (CP 7.219). Since it involves reasoning from consequents to antecedents, abduction is not truth-preserving all or even most of the time. There is no good reason to suppose that the truth must always be among the hypotheses conceivable at a particular time. Nor is there any good reason to suppose that true hypotheses must always be economical (CP 1.120). As result, abduction remains mere “conjecture without probative force” (CP 8.210).

Still, Peirce defends abduction as a legitimate method of science. It is essential to inquiry because it is the only means of introducing novel hypotheses for consideration (CP 5.172). Abduction “furnishes all our ideas concerning real things, beyond what are given in perception” (CP 8.210) and “if we are ever to understand things at all it must be in that way” (CP 5.145). Moreover, since there is no presumption that abductions are true in any definite proportion of cases, the method provides no less than it promises, namely, a hypothesis that might be true. Thus abduction is valid in Peirce’s technical sense, that is, it has “that sort of efficiency in leading to the truth which it professes to have” (CP 2.779).

Of course, it is one thing to claim that inquirers might happen to guess the truth by abduction and quite another to claim that they are destined to arrive at the truth by abductive means. If the truth were beyond the power of inquirers to comprehend, abduction would be doomed to fail and science as a whole would be incapable of correcting itself. As Peirce himself observes, inquiry can only arrive at the truth if there is “sufficient affinity between the reasoner’s mind and nature’s to render guessing not altogether hopeless” (CP 1.121).

But on what grounds might this affinity be supposed to exist? Peirce rejects any sort of *a priori* principle of pre-established harmony between mind and world as a defence of the reliability of abduction. So far as his logic is concerned, inquirers can only hope that there is “some natural tendency toward an agreement between the ideas which suggest themselves to the human mind and those which are concerned in the laws of nature” (CP 1.81). Yet this is not to say that Peirce views the success of abduction as merely a regulative ideal or matter of faith. Whether or not hopes for abduction are justified is a matter of contingent fact not logic. In other words, the thesis that rational inquirers can reach the truth by abduction is a testable hypothesis whose truth may be determined only by empirical investigation (CP 7.220). As Peirce puts it:

> The only method by which it can be proved that a method, without necessarily leading to the truth, has some tolerable chance of doing so, is evidently the empirical, or inductive, method. Hence… [abduction] must be proved valid by induction from experience. (CP 2.786)

Peirce proffers the hypothesis that at least some inquirers can glean the truth by abduction as an explanation of important examples of successful science (CP 8.238). Since false hypotheses are far more numerous than true ones, it would be an extraordinary stroke of luck if the contributions to knowledge of Newton or Darwin, for example, were fortuitous. It is therefore reasonable to suppose there are circumstances in which “man’s mind has a natural adaptation to imagining correct theories of some kinds” (CP 5.591). [3] Peirce thinks this hypothesis is inductively confirmed by its correct prediction of the role of abduction in the continued growth of knowledge. Even though abduction does not lead to true conclusions all or even most of the time, it remains indispensable to inquiry and “induction from past experience gives us strong encouragement to hope that it will be successful in the future” (CP 2.270). While this defence of abduction appeals to results of empirical inquiry in the history of science, it is not circular. As we shall see, Peirce does not presuppose the validity of abduction when justifying induction.

The Validity of Deduction

Once a working hypothesis has been selected, inquiry moves to its second stage: the deduction of testable consequences (CP 7.203). These consequences are expressed by conditionals of the form: "If experiment *A* were performed under conditions *C*, result *R* would occur *p%* of the time". (In the example above, the hypothesis that the coin is unfairly weighted implies that "If the coin is randomly tossed a sufficient number of times, a heads will result in 90% of cases".) Peirce's pragmatic maxim states that the totality of such conditionals implied by an hypothesis constitutes its cognitive meaning. Since the explication of the meaning of a hypothesis does not suffice to determine its truth, the deduction of testable consequences provides no knowledge of material facts.

In defending deduction as a valid component of the scientific method, Peirce distinguishes between "necessary" and "statistical" deductions. In the former the consequences of universal generalizations are deduced, while in the latter the consequences of statistical generalizations are derived. The logical form of each kind of deduction is as follows:

Necessary Deduction

All Ms are P
All Ss are M
Thus, all Ss are P

Statistical Deduction

p% of Ms are P
S1,…, Sn is a numerous random sample of M
Thus, probably and approximately p% of S1,…, Sn are P[4]

Peirce deems necessary deduction valid since in following it inquirers will never be led from true premises to false conclusions. He recognizes, however, that the same cannot be said for statistical deduction. Establishing its validity is a more complex matter.

Consider the hypothesis that a coin is weighted so as to come up heads (*P*) in 90% (*p*) of tosses (*Ms*). By statistical deduction it may be inferred that a random sample of 1000 tosses (*S1,…S1000*) would probably contain approximately 900 heads. This inference is necessary in one sense, since one cannot accept the premises and deny the conclusion on pain of contradiction (NEM 3: 195). However, it cannot be inferred that every random sample of 1,000 tosses would contain approximately 900 heads, since samples with any number of heads from 0 to 1,000 might turn up. All that can be concluded is that among the possible random samples of 1,000 tosses, more would have a number of heads falling within a calculable range of 900 than would not. In other terms, among the set of logically possible statistical deductions based on 1000-toss samples, those with true conclusions would outnumber those with false ones 9 to 1 (CP 2.709). Even though some statistical deductions would yield false conclusions from true premises, true conclusions would be drawn from true premises more often than not given repeated samplings of 1000 tosses. This follows from the law of large numbers, a purely mathematical (i.e. deductive) result that entails that among the possible random samples of a sufficient size (*n*) from a population in which *p%* of members have some trait, "small deviations from *p*… are probable, large deviations, improbable" (NEM 4: 356).[5]

In short, statistical deduction has "that sort of efficacy in leading to the truth, which it processes to have" (CP 2.779) since "precisely analogous reasonings would from true premises produce true conclusions in the majority of cases, in the long run of experience" (CP 2.268). Since necessary deduction yields true conclusions from true premises without exception (N 3:203) it also meets this condition. Hence, deduction in general is a valid component of the scientific method.

The Validity of Induction

Once an hypothesis is formulated by abduction and its testable consequences have been determined by deduction, it remains to test it by induction (CP 2.755). For Peirce, this involves reasoning about an entire class or population based on an examination of a sample of its members. As already noted, the meaning of a hypothesis is expressed in terms of conditionals of the form: "If experiment *A* were performed under conditions *C*, result *R* would occur *p%* of the time". Every hypothesis implies a set of conditionals each of which affirms the truth of a law governing the frequency with which a certain kind of result (eg a coin toss coming up heads) occurs relative to the occurrence of some broader class of event (e.g. random coin tosses in general). Determining the truth of such a law is a matter of inferring the character of an inexhaustible set of logically possible experimental trails (e.g. the set of all possible tosses of a coin) from the finite sample of trials observed to date (e.g. the tosses examined thus far).

Like abduction, induction involves the inference of a law based on a finite set of data. But in abduction the fit between hypothesis and data is contrived by the inquirer who formulates the law and thus it provides no independent test of the truth of the hypothesis. In the case of induction, by contrast, the whole point is to seek out independent data by which to test hypotheses. Thus induction and abduction remain logically distinct forms of inference.

Induction also resembles statistical deduction in that it involves reasoning based on random samples. However, induction is ampliative not explicative. It aims to determine what is true not only what might be the case (N3: 203). And it is valid, according to Peirce, not because it is truth-preserving more often than not, but because it is a self-correcting method (CP 2.781).

In establishing that induction is self-correcting Peirce distinguishes between quantitative induction, qualitative induction and crude induction. He argues for the validity of each form of induction separately.

Quantitative induction has the following logical form:

> *S1,…, Sn* is a numerous and randomly drawn set of *Ms*.
>
> ▯>*r%* of *Ss* are *P*.▯
>
> ▯>Thus, probably and approximately *r%* of *Ms* are *P*.[6]

In the case of the coin thought to be weighted so as to come up heads 90 times out of 100, it may be determined by statistical deduction that a sufficiently large sample of random tosses of the coin would (more often than not) have roughly 90% heads. Suppose that to test this hypothesis the coin is tossed 900 more times and 410 heads come up. Having then obtained a total of 500 heads in 1000 random tosses, it may be inferred by quantitative induction that the coin would come up heads roughly 50% of the time, or in other words, that the coin is fair after all.

Peirce does not think the reliability of a conclusion arrived at by quantitative induction can be determined. The point is not merely that such assessments are fallible but that there are no reasonable grounds– not even fallible ones– for determining the probable accuracy of an inductive conclusion. Even a badly biased coin could appear fair over 1000 tosses and there is no way of knowing whether or not the sample of tosses on which a quantitative induction is based is representative. Nor can it be said, as in the case of statistical deduction, that the conclusion arrived at by quantitative induction would prove correct in a majority of cases were the same sort of inference repeated (CP

2.781). If the coin were tossed 1000 more times, there is no reason to suppose that the conclusion "50% of all tosses of the coin are heads" would be sustained. To the contrary, it is much more likely that the number of heads would vary from sample to sample in which case each new sample drawn would license a different inductive conclusion concerning the propensity of the coin to come up heads.

Still, as Peirce argues, it follows from the law of large numbers that among the set of all logically possible samples of 1000 tosses more of them are reliable than not. This means that if the conclusion that "50% of all tosses of the coin are heads" is based on an unrepresentative sample, then odds are that upon repeating the same sampling procedure that conclusion would eventually give way to one based on a reliable sample. As Peirce explains:

> in induction we say that the proportion [*r*] of the sample being *P's*, probably there is about the same proportion in the whole lot; or at least, if this happens not to be so, then on continuing the drawings the inference will be, not *vindicated* as in… [statistical deduction], but *modified* so as to become true. (CP 2.703) [^8]

The distinction between conclusions of statistical deduction which are "vindicated" in the long run and those of quantitative inductions which are "modified" in the long run is crucial to understanding the relative strength of the two forms of inference. In statistical deduction the character of a sample is inferred from information about the character of the population from which it is drawn. One and the same estimate, p, is inferred to be true of every sample and the inference is justified because p would be true of more samples than not over the long run. Even if a false conclusion should be drawn, the estimated value p will be vindicated in the sense that it will prove correct more often than not. Hence the conclusion, though fallible, is said to be probably true.

In the case of quantitative induction, however, a different estimated value (r1,…, rn) is inferred for each sample drawn. Yet among the set of possible inferred values more are (approximately) true than not. There is no way to tell if a given sample is reliable and thus no way of assigning a probability to the truth of an inductive conclusion (CP 1.92). However, over the long run any estimate inferred from an unreliable sample is likely to be corrected, or "modified", on the basis of a reliable one. In quantitative induction, then, it is the way of proceeding that proves trustworthy, not any particular conclusion (CP 2.780): [7]

> Induction… is not justified by any relation between the facts stated in the premises and the fact stated in the conclusion; and it does not infer that the latter fact is either necessary or objectively probable. But the justification of its conclusion is that that conclusion is reached by a method which,

> steadily persisted in, must lead to true knowledge in the long run of cases of its application… (CP 7.207)

In short, while there is no way to gauge the reliability of a conclusion drawn by quantitative induction, the form of inference remains a valid part of the scientific method because it is self-correcting.

Quantitative induction applies only when there is a population of distinct individuals and it is appropriate to give each member of the population that might be sampled equal probative weight. [8] These conditions do not always obtain. For example, when testing a hypothesis that a particular coin has all the qualities common and peculiar to gold, inquirers must determine its truth or falsehood on the basis of some finite sample of the coin`s limitless properties. Quantitative induction cannot be applied in this case for three reasons. First, qualities are not units that can be counted in a determinate way. If, for example, the coin has a golden colour, then its obverse is golden and its reverse is golden. But there is no definitive answer to the question of whether having a golden colour involves two properties or only one. Since qualities cannot be determinately individuated, there is no precise counterpart to the random selection of individuals that typifies quantitative induction and no way to calculate precisely an appropriate sample size to be examined.

Second, among the qualities of the coin to be tested some are more significant in determining the truth of the hypothesis than others. Passing the test for atomic number provides much weightier evidence for the hypothesis than passing a test for colour or malleability does. Unlike the case of quantitative induction, not all the members of the population to be sampled are to be accorded equal probative weight (CP 2.759).

Thirdly, there is no precise way of quantifying the significance of the various qualities that are examined (CP 7.216; NEM 3: 200). Whether colour is more important than malleability and if so, by how much, is a matter for purely qualitative assessment.

To infer that a coin that passes some of the tests for gold has all and only those properties essential to gold is to draw what Peirce calls a qualitative induction. [9] The inference has the following form:

> All *Ms* have properties *P1,…, Pn*
>
> □*S* has properties □*P1,…, Pn*□
>
> □>Thus, □*S* is □*M* [10]

In arguments of this form, the truth of the premises does not guarantee the truth of the conclusion. Nor is there any reason to think that by examining further random samples of the traits of the coin true conclusions would be inferred more often than not. Still, Peirce deems the inference valid because if a particular conclusion were false, then the error would be discovered through persistent examination of the coin’s remaining properties. If the coin is not gold, then there must be some property common and peculiar to gold that it does not possess and the absence of this property would eventually be revealed through repeated application of qualitative induction. Thus even though the reliability of a particular conclusion inferred by qualitative induction cannot be determined, the method by which it is derived is self-correcting and hence valid.

Neither quantitative nor qualitative induction provides a means for assessing the risk of error in accepting a conclusion as true. Nor is there a way to determine when inductive testing has gone sufficiently far to ensure the avoidance of error. Nevertheless, Peirce recognizes that very often “it does not pay… to push the investigation beyond a certain point of fullness and precision” (CP 1.122). He agrees it is senseless to test a coin after tossing 10,000 heads in a row to see if by chance it might be fair after all. Similarly, he thinks it better to accept that a coin is made of gold on the basis of a small number of significant tests, than to spend a lifetime examining all the properties of the coin or trying to confirm previous findings to some excessively high degree of accuracy. For every line of inquiry there is “an appropriate standard of certitude and exactitude, such that it is useless to require more and unsatisfactory to have less” (CP 1.85).

To decide that further testing of a hypothesis is fruitless is to judge that future experimental results would not depart significantly from those obtained to date. Peirce calls such extrapolations “crude inductions” (CP 7.215). [11] In crude induction an hypothesis is adopted solely on the grounds that it faces no countervailing evidence. It is the weakest kind of inductive justification (CP 7.111) since it leaves the hypothesis “liable at any moment to be shattered by a single experience” (CP 2.757) and there is no anticipating when that might occur. Still, “until the fatal day arrives, [crude induction] causes us to anticipate just what does happen and prevents us from anticipating a thousand things that don’t happen…” (CP 2.757 n1) and thus it has a legitimate role in scientific inquiry. Moreover, for any false extrapolation by crude induction there must be a logically possible counterexample the discovery of which would force inquirers to correct their beliefs. Hence, crude induction is self-correcting no less than more sophisticated forms of induction are.

Science as Self-Corrective

Having established the validity of abduction, deduction and induction, Peirce has to show that taken together they constitute a method that is self-correcting. As noted, abduction, deduction and induction each correspond to a distinct stage of inquiry. Abduction formulates hypotheses from which deduction derives predictions the reliability of which is determined through induction. By adhering to principles of economy in research design, scientific testing will yield maximally informative results at minimum cost. A positive experimental result sustains an hypothesis and leads to its further testing and its application in other domains of scientific inquiry. A negative result eliminates the hypothesis, thereby narrowing the range of possible explanations and providing data on which to formulate new hypotheses. Since induction is self-correcting, testing can be expected to yield a true assessment of each hypothesis.

But how can Peirce claim that inductive testing can always be pushed sufficiently far to ascertain the truth? Every hypothesis implies an inexhaustible set of testable consequences and the experimental results obtained to date is necessarily finite. Surely it is conceivable that the truth is more complex than any finite set of experiences could ever disclose and that the scientific method might fail no matter how persistently it is applied.

Peirce’s answer this objection begins from the recognition that any law implied by the truth of a hypothesis characterizes a relation among an inexhaustible series of possible experiences. A law must be expressible as a rule or formulae since that is the only way to define an inexhaustible series and an indefinable law cannot be the object of a true proposition and thus, for Peirce, cannot be real (5.170). Since the notion of a real law with a definable character at odds with the relations exemplified by the events that instantiate is incoherent, the nature of any law must be realized in some finite set of concrete events:

> For that endless series must have some character; and it would be absurd to say that experience has a character which is never manifested. But there is no other way in which the character of that series can manifest itself than while the endless series is still incomplete. Therefore, if the character manifested by the series up to a certain point is not the character which the entire series possesses, still, as the series goes on, it must eventually tend, however irregularly, towards becoming so; and all the rest of the reasoner’s life will be a continuation of this inferential process. (CP 2.784)

In short, inductive testing is invariably capable of succeeding since every law, however complex, must be exemplified in some finite sample of data. This conclusion rests “upon the necessary relation between the general and the singular. It is precisely this which is the support of Pragmatism" (CP 5.170).

According to Peirce's account of the scientific method, then, as long as there is a truth to know and as long as knowers are endowed with sufficiently reliable powers of abduction, science properly conducted and pushed sufficiently far will eventually lead from any initial state of belief to truth. Since we are warranted in thinking there is a truth to discern and that at least some inquirers are sufficiently adept at abduction to discern it, it is reasonable to think that science has discovered truths in the past and will continue to do so in the future. This is not to predict what future science will achieve, if only because scientists may be annihilated tomorrow or they may fail to undertake the necessary research required for the scientific method to work its charms. However, left to its own devices and barring shortages of minds and resources, the scientific method is a rational means by which to gain the truth.

Objections and Replies

Critics of Peirce's defence of the self-corrective thesis may be classified into two groups: those who claim that Peirce fails to meet his own criteria for a successful defence of the scientific method and those who challenge the adequacy of Peirce's criteria at the outset.

The first line of argument is pursued by Thomas Goudge (1950) who objects that Peirce violates his own strictures on appeals to matters of fact in logic. As Goudge notes, induction– hence science generally– can correct itself only if there are laws among events to be discerned. Yet, according to Goudge, the only logical grounds Peirce cites for accepting that events occur lawfully is that a world devoid of laws is inconceivable. Since Peirce explicitly rejects inconceivability as a criterion of truth, it seems that on his view inquirers must adopt the assumption of a law-governed world as a methodological postulate. However, this leaves the validity of induction as resting on a "material assumption about the constitution of nature" (Goudge, 1950: 193).

Goudge is correct that the pursuit of inquiry presupposes the existence of ascertainable truth as a condition of its intelligibility. Moreover, by Peirce's pragmatic maxim, the assumption that there are truths to know is equivalent to the assumption that reality is governed by laws. However, the pragmatic maxim is a logical rule and, for Peirce, no material truths can be derived from logic alone. Thus, Peirce's defence of induction neither implies nor presumes that there is a reality. His claim is only that if there is a real world, induction would lead inquirers to a correct understanding of it. As noted, this argument relies only on the law of large numbers (for Peirce a mathematical result derived by deduction) and the pragmatic maxim (a non-empirical logical law). If there were no laws, then on Peirce’s view induction would not be invalid, it would merely be inapplicable for there would be no reality to know. In such a world, inquiry would fail to correct itself but not because the scientific method would fall short of the truth but because there would be no truth to attain. That there is a real world– hence a world that is lawful– is an empirical hypothesis but one well supported by scientific results.

A similar worry is raised by Edward Madden’s (1960) claim that in using quantitative induction inquirers must assume that the method of sampling ensures that each member of the population has an equal antecedent probability of being selected. This assumption, Madden argues, has the same import as the principle of the uniformity of nature since it is tantamount to assuming that “the character of the already observed is, under certain circumstances, more or less reliable evidence of some realm as yet unobserved” (Madden, 1960: 254-5).

This objection fails to honour Peirce’s distinction between matters of logic and matters of fact. What methods of sampling are random (if any) and what effect departures from randomness will have on inferences is, on Peirce’s view, an empirical question. While it is true that any particular induction rests on assumptions about the randomness of the sampling method, this only shows that testing a particular belief presupposes the truth of further beliefs– there can be no testing of beliefs one by one. Peirce’s argument for the validity of induction does not presuppose the ability to satisfy the conditions of its application in any particular case. It rests solely on the claim that if induction were correctly carried out and pushed sufficiently far, it would lead to conclusions approximating the truth. Even in crude induction where there is an explicit extrapolation of past results into the future, there is no prior assumption that the future must be like the past. Any such extrapolation is subject to further tests and is falsifiable by counterexample.

The second common line of argument against Peirce is that his defence of scientific results is too weak. On Peirce’s theory, there is no way to measure the probability that an inductive conclusion is true and no way to know when inquiry has been pursued sufficiently far. Peirce leaves unanswered the question of which scientific results can be regarded as knowledge for purposes of applied science and everyday life. All that can be claimed for a particular result is that it is a provisional step in an indefinite process of inductive investigation. [12]

What is presented here as an objection is, for Peirce, an accurate statement of the epistemological predicament. To illustrate this point, Peirce imagines someone whose life depends on his drawing a red card from a deck in a single try. It would be more reasonable for this person to draw from a deck containing ten red cards and one black than from a deck stacked the other way around. Yet to say the probability of drawing a red card is higher in the former case is only to say that the frequency of red cards drawn with respect to the total number of draws over the long run of experience is greater than in the latter case. But knowing this provides no rational basis for forming expectations about whether a single draw will turn up a red card or not. For Peirce this shows that:

> the idea of probability essentially belongs to a kind of inference which is repeated indefinitely. An individual inference must be either true or false, and can show no effect of probability; and, therefore, in reference to a single case considered by itself, probability can have no meaning. (CP 2.652)

Peirce thinks the epistemological situation of a finite inquirer differs from this example only in degree (CP 2.653). The life of an inquirer is finite. Yet the scientific method guarantees self-correction only over an indefinitely long run of experience. For Peirce, this means that the pursuit of truth requires the adoption of theoretical goals that transcend the interests of any individual (CP 2.653). "[L]ogicality inexorably requires that our interests shall not be limited. They must not stop at our own fate, but must embrace the whole community [of inquirers]" (CP 2.654). On this view, propositions that science accepts at a given moment:

> are but opinions, at most; and the whole list is provisional… pure theoretical knowledge, or science, has nothing directly to say concerning practical matters, and is not even applicable to vital crises. (RLT: 112)

For Peirce, then, the hankering for a means of certifying provisional scientific results as likely to be true is precluded by the epistemological circumstances of finite rational knowers. There is no cause for scepticism, however. For on Peirce's view, the methods of science are self-correcting and the prospect of attaining truth in the end is assured.[13]

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Notes

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1. Nicholas Rescher (1978) rightly takes Larry Laudan (1981) to task for assuming that Peirce intended to show that each form of inference is warranted in the same way, namely, that it is self-correcting, and Gordon Pinkham (1967) rightly criticizes Chung-ying Cheng’s (1966, 1969) claim that the principles involved in Peirce’s defence of induction and statistical

deduction are one and the same. ↩

2. At various times Peirce calls this form of inference “hypothesis” (CP 8.229), “hypothetic inference” (CP 8.383), “retroduction” (CP 6.470, CP 7.97) and “presumption” (CP 2.776). The differences between Peirce’s early notion of “hypothesis” and his later views on “abduction” lie outside the scope of this article. ↩
3. As Peirce cautions: “it is one thing to say that the human mind has a sufficient magnetic turning toward the truth to cause the right guess to be made in the course of centuries during which a hundred good guessers have been unceasingly occupied in endeavouring to make such a guess, and a far different thing to say that the first guess that may happen to possess Tom, Dick or Harry has any appreciably greater probability of being true than false” (HP2: 901). ↩
4. One could view necessary deduction as a special case of statistical deduction, namely, the case in which $p = 100$, were it not that statistical deduction requires that the sample be random and that the character be designated in advance of the inference. See Levi (1980). ↩
5. Peirce defines probability as the “ratio of frequency in the ‘long run’ of experience of designated species among experience designated, or obviously designable, genera over those species…” (CP 2.763). By “the long run” he means an indefinite set of possible trials. Probabilities refer not to results that will be observed in the future nor even to results that would be drawn if inquiry were prolonged indefinitely but to the totality of logically possible results. Since the set of logical possible trials is inexhaustible, Peirce amends his definition of probability to refer to the limit of the relative frequency of true results with respect to total cases in an endless series (CP 2.261). Thus, to say that the probability of a coin coming up heads is 1/2 is to say that 1/2 “is the only value of [the] quotient that it will not sooner or later become larger than or smaller than *for the last time*…” (NEM 3: 175). ↩
6. For this inference to be valid, for Peirce, the characteristic P must be “predesignated”, that is, it must be specified in advance of drawing the sample. See Goudge (1950: 162f). ↩
7. “In deduction we know the probability of our conclusion (if the premises are true), but in the case of synthetic inferences we only know the degree of trustworthiness of our proceeding” (CP 2.693) given that it is a self-correcting method. The conclusion of an induction is adopted “provisionally, until further evidence is obtained” (NEM 3: 197). ↩
8. This is implied by the requirement that the sample be random: “A sample is a *random* one, provided it is drawn by such machinery, artificial or physiological, that in the long run any one individual of the whole lot would get taken as often as any other” (CP 1.93). ↩
9. In an earlier paper (1989) I wrongly claim that the differences between quantitative and qualitative induction are negligible. ↩

10. Like quantitative induction, qualitative induction is subject to the requirements of random sampling and “predesignation” (2.735-740 and 2.788-790). ↩
11. Crude induction is also called “rudimentary induction” (CP 7.111) or “pooh-pooh argument” as it “consists in denying that a general kind of event ever will occur on the ground that it never has occurred” (CP 2.269). See also CP 2.756, CP 2.758 n1, 8.237, NEM 3: 193 and NEM 3: 200. Rescher (1978) wrongly claims that crude induction is an insignificant part of Peirce’s theory of science. ↩
12. See Madden (1960: 255). Lenz (1960: 302) raises a similar objection against Hans Reichenbach while equating Peirce’s view with Reichenbach’s. ↩
13. I am grateful to Andrew Lugg for helpful comments on this article. ↩