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Historical Document

On Probable Knowledge

A dissertation submitted for public examination in the plenary meeting of the Faculty of Philosophy at Uppsala in the Hall of Charles the Great, 30 May 1767

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[On the title page is written in an early C19 hand: "Presented by Dr Collin, March 18th 1803." On the following page in a different hand: "presented to the American Philos. Socy. at Philada. by Dr N Collin 18 March 1803"]

> It is not just to search for certainty in proof and scientific investigation of things which can only be known in a probable way, nor yet is it in our grasp to know these things more perfectly.
>
> LOCKE

[There follows a two-page poem in Latin elegiac distichs by Olav Bergklint, "To the Author," not translated].

1. As man is endowed with the power of reasoning, I could not think of anything that suits him better than to exercise this distinguishing gift by investigating that which is true and certain.

But man's intellect cannot reach the innermost structure of nature at every point; so we have to confess that, if we are to give an opinion about most things we encounter either in the scientific context or in everyday life, quite a number of reasons and arguments are not seen by the acute intellect. As long as we do not know in which sense these reasons contribute to the confirmation or otherwise of the matter under discussion, we cannot safely make any statement about the subject.

Logicians call these reasons and arguments which make any proposition be judged as a true one requisita ad veritatem [= things necessary for the truth. We translate the phrase hereafter as "conditions for truth" or as "evidence"]. But if some necessary reasons are present, but do not suffice for the truth, our cognitio [we translate as "knowledge"] is called probable.

However, a wise man suspends the process of judgment, and will not unnecessarily base his judgment on a pure fortuitous probability, about things that either can be known with certainty or are of little importance to know about. Likewise, a man would be wise who never undertakes anything without being certain in every point about the successful outcome, but our condition of life would be very miserable and

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our days would languish with idleness and lethargy if we followed only certainty in all things we wish to undertake. (Consider the sailor who does not want to start out from the harbor, although the bright sky and the gentle winds promise a successful trip, because heavy storms, whirling and rushing in different directions, might perhaps throw him off course once he has reached the open sea). Therefore necessity, which is called 'the needs of the occasion' or 'the need to choose', does not so much coax as force us to include probable statements and to acknowledge them as leaders in directing our lives, where there are no better principles.

Having reached this point, it is most necessary for everybody who wants to organize his affairs providently, to weigh with meticulous care how far he is away from certainty. We have decided to offer some ideas concerning this problem, touching on the most important as our first attempt. We wish to ask you, C.L. [the dedicatee], with all due deferential regard, to look at our innocent beginnings with favor.

> ARISTOTLE erroneously explains eikos ('seeming to be consistent with the facts' – Anal. Pr [2] 27 [70a2 sqq]) and endoxon ('probable, based on an opinion rather than on knowledge' – Top. 1 [1. 100b 21 sqq]) as that 'with which all agree, or most, or the wise, and of them all, or most, or the most famous and renowned'. Now, I do not want to speak about the many foolish sayings that do not even pretend to have any probability, but that are so common among people who believe in them (although they are so obviously rubbish) as if they were uttered by an oracle. Only very rarely will you find that the same things please the lowest people and the wise. There is no time here to discuss the other, different, opinions erroneously offered by philosophers who give a definition of the probable.

> Probability is not about things themselves but about our knowledge of them. Therefore we have no firm basis for decision: to one man, a thing seems probable which to a more perspicacious person is certain, and probable knowledge can be changed to certain. Therefore we cannot agree absolutely to that well-known principle – to doubt everything – that DESCARTES recommended to the philosophers, because, apart from other considerations, there are so many ideas whose truth or falsity is so very obvious by simple juxtaposition that approval cannot reasonably be withheld.

2. Somebody who is content only to list the arguments and cares little about weighing them strays far from the truth. Therefore the degrees of probability have to be calculated on the basis of the quantity and weight of the evidence we know in relation to the quantity and weight of those things which are not known or which seem to speak in favor of the contrary. Depending on the result of this calculation, that is whether one or the other part prevails, we distinguish different types of probable propositions, probable in the strict sense, doubtful or ambiguous, and improbable or dissimilar to the truth. But if you look at our assent, there are once again different names for different degrees of probability: e.g. assent, opinion, conjecture, doubt, disbelief etc. Therefore it is convenient to distinguish in the field of probability, as

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with truth in general, between material and formal: our first distinction belongs to the former, our second to the latter.

> Somebody who is concerned with evaluation of the evidence cannot bee too careful about keeping his mind free from all preconceptions. Because the idols of logic, as BACON calls them, claim a veneration that is due only to truth, one can hardly tell how much they impede the right estimation of men's arguments. Usually we give the most authority and influence to those considerations which accord with our opinions and decisions, and try hard to turn our eyes from those which do not. All the more so because it is easier to resist a merely persuasive probability than a truth which commands assent with full evidence.

3. The evidence by whose force a predicate is attributed to a subject is either internal to the subject – that is determined by the concept of the subject itself – or external – that is dependent on other things. Therefore two types of probability come into being, depending on whether internal or external evidence is used. To the first type belong cognitions we attain by examining the very nature of the subject; to the second belong cognitions we achieve through the external senses or other testimonies.

> Some people say that there are different types of probability: historical probability, moral, practical, physical and hermeneutical. To these types others add the medical, the ambiguous and the human; others add yet other types. We believe that our distinction seems to be the most adequate to the particular quality of the matter, since this distinction is derived from the ways by which we achieve knowledge.

4. Since it is not right to believe that we are always deluded by idle phantasms, nor that life is nothing but a series of dreams, there is no doubt that the perceptions of our external senses are always true, in the sense that they depict the alterations effected on the sensory organs by the objects. But the same objects can be situated in different relation to the senses, or different objects in the same relation (by varied position, distance etc). Therefore everybody who forms a judgment about external things based on the senses must first have knowledge of the rules which the senses observe in different circumstances, and must pay attention to the degree of importance the individual rules have in the present case. Otherwise, they risk embracing the cloud instead of Juno as they form their judgments [a reference to Greek myth, cf. Apollodorus *Epit.* 1.20]. But the more rules one takes into consideration whilst forming a judgment, the higher the degree of probability attained by the knowledge reached by one's senses.

> To somebody who sits in a boat moving quickly and steadily, 'land and cities recede' [quoting Virgil, *Aeneid* 3.72]. But if he has been taught the principles of optics, then he understands that the phenomenon does not suggest a motion of the object but rather of the eye. Somebody who does not know how to infer from the apparent dimensions to the real ones would easily think that the diameter of the sun is less than two feet; but somebody who knows that one has to consider the distance will suspend judgment until he can calculate the true size after having found out the distance.

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But nevertheless we do not agree with those who do not trust at all in the cognition of their senses, and who do not have methods that explain the rules valid for the senses. These philosophers have themselves found a way of judging things that surround them and that they have grasped quite often with their senses; this way of judging is to a very high degree comparable to the method of science. Nevertheless these people should be advised not to go beyond cases similar to those they have examined before.

5. The more obvious it is that at least not all qualities of an object can be sufficiently perceived by one sense only, the more necessary it is that the senses help and support each other. Therefore, the more numerous the senses and perceptions which contribute to our external cognition, and the more carefully the rules we introduced earlier are observed for every single sense, the closer our cognition is to the truth.

But I do not want to say that the perception of one sense can be interfered with by another in any way, but rather that the perceptions of different sense are different in all regards: as witness the example of the young blind man quoted by D. SMITH (Compl. Syst. of Opt. Bk 1 ch. 5). This young man was able to distinguish everything correctly just by touch. But when he got back his sight, it took him some time to distinguish things from one another with his eyes.

6. Somebody who wants to support his cognition by what other people say must adjust his assent after making a judgment about the witness's competence and sincerity. Therefore one has to check whether the witness is competent in the matter he gives witness of, whether he owes his cognition of the matter to his own experience or to the witness of others, whether he confounds his judgment about the matter with the matter itself, whether he might expect some benefit from his being a witness, what was his intention in giving his witness, whether he expresses the same notions with the same words as we do, and whether single parts of the testimony cohere with one another or with the truth. If there are several witnesses, one must pay attention to their number and their quality, to whether they attest contradictory things etc.

Hence it is easy to understand how much care and how many precautions are necessary to estimate correctly the probability that depends on the witness of others. Those who use arguments from Holy Scripture to declare that the earth does not move, cling to the words rather than to the intention of the Most Holy Author and try, unaware that they are deceived by the witness, to support an absolutely wrong theory. Therefore nobody can be in doubt about how he must judge merely human witnesses, where we may be at a loss for the aforesaid reasons. Therefore some philosophers alleged that no historical cognition can pass the limits of probability. But nevertheless let us, for the sake of argument, assume that it might be perfectly possible that the great Gustavus I never existed, but that so many people all united have conspired to build up this construction of lies, so coherent that the illusion in no way revealed itself; and that for that purpose they might have ensured throughout their lives that nothing which might contradict the fiction would leak out, and that these people would be aware that they would have no rewards for all these labors but that futile delight of seeing other people plunged in

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error – all this, I think, is morally so impossible that I could never suspect it seriously, not even for a second.

7. To understand internal evidence – that is evidence which follows necessarily from the nature of the subject – and the determinability of the predicate, we must understand the different ideas of the subject and its determination. The probability of the reasoning [*probabilitas rationis*] comes the nearer to the truth, the more distinct we have got our notions of the subject.

From the theory of planets, we suppose that planets are dark bodies that move, similarly to our own earth, round the sun and their own axis; and because we think it apt for the divine wisdom and benevolence that nothing is ever made in vain, we think that the planets are probably inhabited by intelligent beings. But then we notice that the planets are very different from the earth because of their distance from the sun, their size, their density, their motion, both axial and orbital. So we declare with all probability that they cannot be inhabited by human beings – as no tropical plant can bloom richly in the Lapp winter. But the confusion of our ideas about the nature and purpose of the planets, and about the nature of organic bodies, prevents us from declaring that anything in these hypotheses is certain.

The mathematical sciences owe their clarity first of all to the very simple and therefore distinct ideas, such as dimensions, numbers, etc., which they deal with. This clarity is praised very much for its own sake and adds much to our appreciation of the mathematical sciences.

8. For every proposition to be examined by reasoning, and for each subject, sufficient reason must be shown for attributing a predicate. As it is most important, in philosophical matters concerned with evaluating the probabilities of hypotheses, to search for causes, this will be discussed here.

A hypothesis is a proposition that we take as true – not because it can be proved, but because by using it we can give reasons for certain things. Therefore, whoever must give a reason for something and its changes and to this end formulates a hypothesis must check carefully whether the assumed cause really exists and can exist together with the object examined, but also whether it has an effect on this object and whether this effect corresponds to the observed changes of the objects examined. Step by step, the probability of a hypothesis can finally reach the status of a certain truth. But if even one phenomenon contradicts the hypothesis, then it must rightly be rejected as false.

It would be advisable that everybody who constructs hypotheses should be as prudent as the immortal NEWTON. He did not proclaim as true his hypothesis about gravity as the cause of the motion of all the heavenly bodies, in his sublime work Principles of Natural Philosophy, until he had shown that this attraction really existed and that his model could explain not only all orbital motions of the planets but also the smallest variations in these motions. Therefore one can rightly admire the Newtonian

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> theory of gravity as the fruitful mother of the most subtle truth in astronomy. But we rightly repel DESCARTES' 'vortices' from philosophy, even if they might explain the motions of the planets in whatever manner: on the one hand because it is not yet proved that such vortices do exist; on the other hand, because the motion of the heavenly bodies is never found to follow these vortices, how elaborately so ever they are constructed.
>
> Earlier generations were prone to form hypotheses just from the fact that things coexisted or fitted together to some extent. They even rushed to make useless statements where facts were missing. For such statements they then fought as if for hearth and home, and cared little about further examination of their hypotheses. With their fictions they utterly ruined philosophy and hindered its further perfection. More recently, some people wanted to cure this evil – and as it happens in most such cases, they are mistakenly going to the opposite extreme. They stated tenaciously that all hypotheses must be banned from philosophy and that they must be avoided like the plague. But since the nexus between cause and effect can only rarely be recognized at once from the evidence of the senses, and one usually has to try to conjecture like a child, we believe that hypotheses are a very useful method in philosophy, as long as they are treated as such until it is shown that they are true. For other points on this theme refer to the honorable RIDIGERUS on The Meaning of True and False – where also many excellent treatments of probability are found.

9. Because we are convinced that all things are directed by certain and unchangeable laws, we deduce very often either from the observed consequences of some things the consequences of things that are similar to the observed ones, or from the result in some case or another result in a similar case. Logicians call the first method induction or analogy, and the second expectation of similar cases. With both methods, we infer from the similarity of the defining factors to the similarity of the things defined. Therefore in these cases the probability rises, the more certainly and distinctly the similarity of the cases and all the circumstances has been established.

> In the same way, since observation shows that Jupiter, Mars, Earth and Venus are moving in orbital motion round an axis, astronomers conclude with probability that both Saturn and Mercury are affected by that motion, although it has not yet been possible to observe this. We have often seen that a magnetic needle is disturbed by the Aurora Borealis. Hence we expect a similar movement of the needle as soon as the Aurora Borealis appears. To some extent ARISTOTLE's semeion ["sign"] belongs in this context: he defines it in Anal. Pr. [2] 27 as ['a demonstrative proposition necessarily or generally approved; for] anything such that when it is another thing is, or when it has come into being the other has come into being before or after [, is a sign of the other's being or having come into being.'][1]

10. In those things that chance so directs that we cannot see any reason why they go in one direction rather than in another – since only cases from which something may flow

[1] Collin and Prosperin mangle Aristotle at this point. They quote not the definition of a sign but an explanatory phrase. By omitting the sections in square brackets (from the translation in Ross (1926, vol. I) they garble the sense of the original.

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provide relevant evidence – their degree of probability follows certain rules. The rules for probability, by which one expects one thing rather than another, follow a method that relates the number of cases by which one event is reached to the number of cases which lead to another. Consider games of dice. Since there are six faces of the die and therefore six different cases to be expected, it is five times more likely that a number other than 6 results from a throw, so that the probability of 6 in the first throw is 1/6. Therefore, if among several events one is to be expected, but it is uncertain which one, the expectation for it should be regarded as the sum of the products from the number of cases which produce it, divided by the number of possible cases. Let A, B, C, D etc be outcomes, and q, p, r, s etc the numbers of cases by which each of these outcomes may arise, and n the total number of cases. From the foregoing, the expected value of obtaining A is (q/n)A and so on, such that the total expected value is

$$\frac{qA + pB + rC + sD \ldots}{n}$$

These things are so very clear that nobody who wants to organize his affairs providently when they are influenced by chance should ignore these principles. Somebody who must calculate the annual yield of a piece of land sums up the yields of several previous years and divides it by the number of years. If the observations of an astronomer differ one from another and there is no reason why he should rely more on one than on the others, then he follows the mean value, as the safest way of proceeding. We have introduced these principles because they are so largely used that our entire theory of probability is based on them, and because they can be applied to every investigation in the field of probability.

11. What we have discussed so far is especially concerned with the manner of calculating the degree of probability for the forming of judgments. It remains to examine the manner of calculating on the basis of [merely] probable premises. Here we must candidly confess that we are abandoned by the work of the logicians. Of course they teach that if one or both premises are probable the conclusion will be probable too. But if the question arises: 'How can the probability of a conclusion be calculated, given the degrees of probability of the premises?', I believe we meet a deep silence, especially if a lengthy series of calculations is required. This will surprise nobody who knows that the theory of calculation and of combination are here of equal importance – and both belong to another discipline.

As this is not the place to explain the rules of the method the mathematicians use for their theory of probability, and as it is easier to understand such methods from examples than from rules, I give at least one application of the method: the calculation of the chances in the very well-known game of 'cinq et neuf'.

Let there be two players, A and B, of whom A throws first ('kastar') and B proposes the prize for the game ('håller'). Player A, who throws, can either lose with his first try (if he has thrown either 5 or 9), or win (by throwing the same with both dice ('Allor') or 3 or 11), or the game continues (if with the first throw he gets 4, 6, 7, 8 or 10). First of all, the value of the undecided outcome must be calculated.

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Let us suppose he has thrown 4 or 10 at the first try. Because with two dice there are 3 cases which lead to [each of] 4 or 10 (by the mathematics of combinations) and 8 which give either 5 or 9, the probability of his continuing in this case is 3/11 (from Section 10). Now let us suppose that he has got 6 or 8 with his first throw. Since there are 5 cases for [each of] these two numbers, his probability of continuing is 5/13. By the same mode of calculation it is clear that his probability of continuing if he throws a 7 in the first turn is 3/7. [Translators' Note: The cases discussed in this paragraph. seem inconsistent with the rules stated in the previous paragraph. In each case the fraction is made up by (n of cases leading to given outcome)/{(n of cases leading to given outcome) + (n of cases leading to 5 or 9)}. A.B.U. and I.M.] But before the first throw it is clear that there are 10 cases altogether which give the whole prize to player A (6 cases for doubled numbers, 4 for 3 and 11 – two for each) and there are 8 in which A's hope fails. Besides, there are six events for 4 and 10; but these six include the two pairs, which we have already treated, therefore four events remain, giving a probability of 3/11. In the same way, the remaining eight [non-double] ways out of ten for 6 or 8 give a probability of 5/13. Finally, there are six events for 7, which give a probability of 3/7.

Therefore, since there are 36 different possible throws with two dice, and as many events, it is clear from Section 10 that the probability of A's winning is

$$\frac{10 \times 1 + 8 \times 0 + 4 \times 3/11 + 8 \times 5/13 + 6 \times 3/7}{36} = 4189/9009$$

and consequently that of player B is 4820/9009, so that it is more probable that he will win than player A. This is clearly the contrary to the usual calculations of those who like to entrust their fortune to the vicissitudes of such games.

In a similar way the calculation of probability for everything in civil, moral and economic matters could be inferred. But our work is especially interested in the countless varieties of uncertainty in everyday life, which only a madman would wish to know in advance. But nevertheless the renowned Jacob BERNOULLI (Ars Conjectandi Pt. IV chs IV and V) showed that the various events can be calculated as precisely as possible from the results previously observed very often in similar examples. This and other great things achievable by algebraic calculation made such an impression on that great man that he did not hesitate to declare that 'in the reduction of the simplest algebraic equation is hidden more talent than in the most difficult calculations that occur in daily life' (Parallels between the reasoning of logic and algebra Theorem 16). In this opinion D. MALEBRANCHE seems to agree with him. He plainly confesses that 'algebra is the most useful logic for the capacity of the mind to detect truth and extend it as far as possible' and proclaims that 'he does not believe that there is anything useful for mankind that cannot be achieved with the help of arithmetic and algebra' (An Inquiry into Truth Book VI ch. V).

But in this context we cannot conceal the fact that there are some doubts about the mathematical principles of the calculation of probability. These doubts were recently expressed by the most important philosopher of our time D. ALEMBERT [sic] (Mathematical Works Vol. II). Everyone who recognizes his most famous name will readily acknowledge their importance. But this is not the occasion to discuss his controversial

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results. So we give the finishing touches to our work, and are quite confident that no benevolent reader will make inferences in matters of probability about the [expected] value of human actions, based on just one or two events. As the judgments of the vulgar are utterly misguided, 'if something that has been carefully prepared fails, then even Cato will be thought to be stupid in the eyes of the people'.[2]

[2] The phrase between quotation marks is a Latin distich. It is evidently a version of a well-known saying connected with the proverbial wisdom of Cato.

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