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Who Discovered Bayes's Theorem?

STEPHEN M. STIGLER*

One of the most popular early television shows of the 1950's, at least in our household, was Groucho Marx's quiz show, "You Bet Your Life." The questions in this show were secondary, the humor primary, and occasionally a hapless contestant would find himself bankrupt at the end of the regular session. Groucho would then give the unfortunate a bonus question; often it was "Who is buried in Grant's tomb?" I have since learned that such questions can be treacherously more difficult than they appear at first sight. In science, designations such as Chebychev's Inequality, Fourier Transforms, or Bayes's Theorem are called eponyms, and they are ostensibly named after their first discoverer. Yet this cannot be taken for granted; to the contrary, it seems to be a law of the sociology of science that no discovery or invention is named after its first discoverer ("Stigler's Law of Eponymy," see Stigler 1980; see also Merton 1965). What follows is an investigation into the validity of this Law in the case of Bayes's Theorem, an attempt to answer the question, who *was* the first to discover Bayes's Theorem?

The first, most obvious answer, the answer that might have been given had Groucho used this question on "You Bet Your Life," is Bayes himself. Indeed, Thomas Bayes (1702(?)–1761), an English dissenting minister who lived in Tunbridge Wells from 1731, has an established historical connection with the Theorem. (See, e.g., Stigler 1982.) Richard Price found it in Bayes's papers and arranged for its posthumous publication in 1764, and until recently, no earlier claimants had appeared. But the Law of Eponymy tells us that such a situation could not exist indefinitely, and sure enough, some intriguing evidence has recently come to light.

The evidence is a passage in a 1749 book by David Hartley, *Observations on Man,* and its significance was, apparently, first remarked on in print by an English psychologist, Bernard Singer (see Singer 1979, p. 6). The passage was independently called to my attention by a colleague, Sandy Zabell. Hartley's book is not an obscure one; he is known as the founder of association psychology, and the book is his major work. But his comments on probability seem surprisingly to have escaped notice until recently. In a section of the book on "propositions and the nature of assent," Hartley discussed the role of probability in the assessment of evidence. Only two paragraphs, on pages 338 and 339, need concern us here. The second is reproduced in Figure 1. The first is a clear and straightforward report on De Moivre's limit theorem for the binomial, or at least on some of the consequences of that theorem. It is the second of the two paragraphs that catches our eye and quickens our pulse. "An ingenious Friend," Hartley confides, "has communicated to me a Solution of the inverse Problem. . . . " He then gives a concise statement of Bayes's problem and a consequence of its solution. What, we ask, do we have here?—Bayes's Theorem 12 years before Bayes's death, and 15 years before Price published the paper? Who *was* this ingenious friend? Could it have been Bayes? If not Bayes, then who?

This is a whodunit worthy of Hercule Poirot or Nero Wolfe. A body (of work, Bayes's Theorem) is found and a single piece of hearsay evidence (Price's testimony; the manuscript does not survive) is used to convict Bayes, who is dead and cannot testify in his own behalf. Later, new evidence surfaces that the body may have been there before Bayes came on the scene. It is time to reopen the case.

Where shall we begin? A naive approach would effectively start from scratch, with a directory of 18th century mathematicians. For example, we might open E.G.R. Taylor's (1966) *The Mathematical Practitioners of Hanoverian England 1714–1840,* or P.J. Wallis's (1976) *An Index of British Mathematicians, Part 2, 1701–1760,* and we would find that a John Good of Seething Lane, London, taught mathematics at about that time. Could the Theorem in question be Good's Theorem? But this approach is surely the wrong one. Wallis lists about 4,500 names, and how can we decide between Good and Jefferys and Fisher and Cochran and Cox and Barnard—all worthy names in Wallis's *Index*? This unguided dredging soon yields to wishful thinking—would that John Doubt or John Pretty was the discoverer, or that the Theorem was proved by James Short in one of his famous short proofs, or that it could be traced to Sally Sweetlips (Wallis p. 111), to Benjamin Bastard (p. 8), or to the joint work of Holmes and Watson (pp. 57 and 122), Redford and Newman (pp. 94 and 82), or Knight and Day (pp. 66 and 30). Clearly a more scientific approach is called for.

I decided to start with the obvious inspiration for Hartley's friend's work, Abraham De Moivre. De Moivre's limit theorem grew from his *Miscellanea Analytica* of 1730, first appeared in a Latin pamphlet of 1733, and finally appeared in English in 1738 in the

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OBSERVATIONS

ON

MAN,

HIS

FRAME,

HIS

DUTY,

AND HIS

EXPECTATIONS.

In TWO PARTS.

By DAVID HARTLEY, *M. A.*

LONDON,
Printed by S. RICHARDSON;
For JAMES LEAKE and WM. FREDERICK,
Bookſellers in *BATH:*
And ſold by CHARLES HITCH and STEPHEN AUSTEN,
Bookſellers in *LONDON.*
M.DCC.XLIX.

the Nature of Aſſent. 339

Cauſes of the Happenings muſt bear a fixed Ratio to the Sum of the Cauſes of the Failures.

An ingenious Friend has communicated to me a Solution of the inverſe Problem, in which he has ſhewn what the Expectation is, when an Event has happened *p* times, and failed *q* times, that the original Ratio of the Cauſes for the Happening or Failing of an Event ſhould deviate in any given Degree from that of *p* to *q*. And it appears from this Solution, that where the Number of Trials is very great, the Deviation muſt be inconſiderable: Which ſhews that we may hope to determine the Proportions, and, by degrees, the whole Nature, of unknown Cauſes, by a ſufficient Obſervation of their Effects.

The Inferences here drawn from theſe two Problems are evident to attentive Perſons, in a groſs general way, from common Methods of Reaſoning.

Let us, in the next place, conſider the *Newtonian* differential Method, and compare it with that of arguing from Experiments and Obſervations, by Induction and Analogy. This differential Method teaches, having a certain Number of the Ordinates of any unknown Curve given with the Points of the Abſciſs on which they ſtand, to find out ſuch a general Law for this Curve, *i. e.* ſuch an Equation expreſſing the Relation of an Ordinate and Abſciſs in all Magnitudes of the Abſciſs, as will ſuit the Ordinates and Points of the Abſciſs given, in the unknown Curve under Conſideration. Now here we may ſuppoſe the given Ordinates ſtanding upon given Points to be analogous to Effects, or the Reſults of various Experiments in given Circumſtances, the Abſciſs analogous to all poſſible Circumſtances, and the Equation afforded by the differential Method to that Law of Action, which, being ſuppoſed to take place in the given Circumſtances, produces the given Effects. And as the Uſe of the differential Method is to find the Lengths of Ordinates not given, ſtanding upon Points of the Abſciſs

Z 2 that

Figure 1. Title Page and Page 339 From Hartley's Observations on Man *(1749).*

second edition of the *Doctrine of Chances*. Clearly, the "ingenious friend" had read De Moivre. Now the first of these works, the *Miscellanea Analytica* of 1730, is unusual in that it carries with it a list of its readers! The work, like several of the time, was sold by advance subscription, and the list of subscribers was printed with the book (see Figure 2). Could the "ingenious friend" be on this list?

At this point, things were looking up, for there are only 62 names on the list, several of which can be ruled out as foreign, as libraries, or as idle royalty or nobility who were merely subscribing to help support the impecunious De Moivre. But there are still too many names, including those of John Arbuthnot, John Craig, Colin Maclaurin, James Stirling, and Brook Taylor. Or could it have been Lady Diana Spencer? Or was Hartley throwing us a hint—could the "ingenious friend" have been Dr. John Friend? No, there are too many suspects to invite into a drawing room for a dramatic dénouement. The one salient fact we may note, however, is that Thomas Bayes is *not* on the list.

At this point I focused my investigation on the principal nonsuspect, the source of the evidence, David Hartley. Perhaps I could discover a list of Hartley's friends. And here I came upon the first clues of real importance. Hartley was at various times active in scientific circles in London, and he lived much of his adult life in Bath. He was given to the devoted support of innovative products, not always with happy results. A certain Mrs. Stephens claimed to have discovered a successful treatment for kidney stones. Hartley suffered from this malady, and he wholeheartedly adopted her cure and expended great energy in spreading the word far and wide. The nature of Mrs. Stephens's cure was not revealed (it was a trade secret), but its efficacy can be doubted. Hartley himself died of "the stone" in 1757, at the age of 52. Rumor had it that by his death, he had ingested over 200 pounds of soap (see Turner 1883). Mrs. Stephens is *not* a likely suspect.

Another of Hartley's causes was a system of shorthand invented by the poet John Byrom (see Figure 3). Byrom, a Fellow of the Royal Society, and the author of "Christians, Awake, Salute the Happy Morn," taught the system to Hartley in the early 1740's for £5, and Hartley embraced it eagerly. With the zeal of the newly converted, Hartley took up Byrom as a project of his own and sought to organize a subscription list for Byrom's system, so that it might be printed and made available to all. Now, Byrom left an extensive journal in which he recorded all his movements and conversations, in shorthand, naturally. The journal, fortunately, was transcribed and published in the 1850's (see Byrom 1854–1857). We know where Byrom was from 1725 to 1750, whom he saw, and what they talked about. He saw Hartley frequently, at Hartley's home and at the Royal Society. He saw Hartley's wife even more fre-

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Figure 2. Subscription List from the Miscellanea Analytica *(De Moivre 1730).*

quently, although he recorded few details of the "shorthand lessons" he gave her, other than that "she seemed much pleased with it."

Byrom never discussed probability with Hartley, or with anyone else for that matter. The major piece of evidence to emerge from four volumes of Byrom's testimony is negative. He places hundreds of people in contact with himself, and many of these with Hartley as well, but Thomas Bayes is not mentioned even once. Our suspicions rise that an innocent man has been falsely accused of originating that Theorem. But if not Bayes, then who?

Our first real suspect comes from two different sources, one a sketch of the life of Hartley that prefaced an 18th century edition of his works (see Pistorins 1801), the other an extensive collection of correspondence between Hartley and his good friend John Lister, much of which was published in the *Transactions of the Halifax Antiquarian Society* in 1938 (see Trigg 1938). John Lister is not our suspect—the letters show him to have been innocent of any knowledge of mathematics—but he helps lead us to someone else. For it seems that there was one remarkable mathematician that Hartley counted among his friends, the man who taught him mathematics while he worked on his book. That man was Nicholas Saunderson.

Saunderson (sometimes spelled Sanderson) is not

Figure 3. John Byrom, From Byrom (1854–1857).

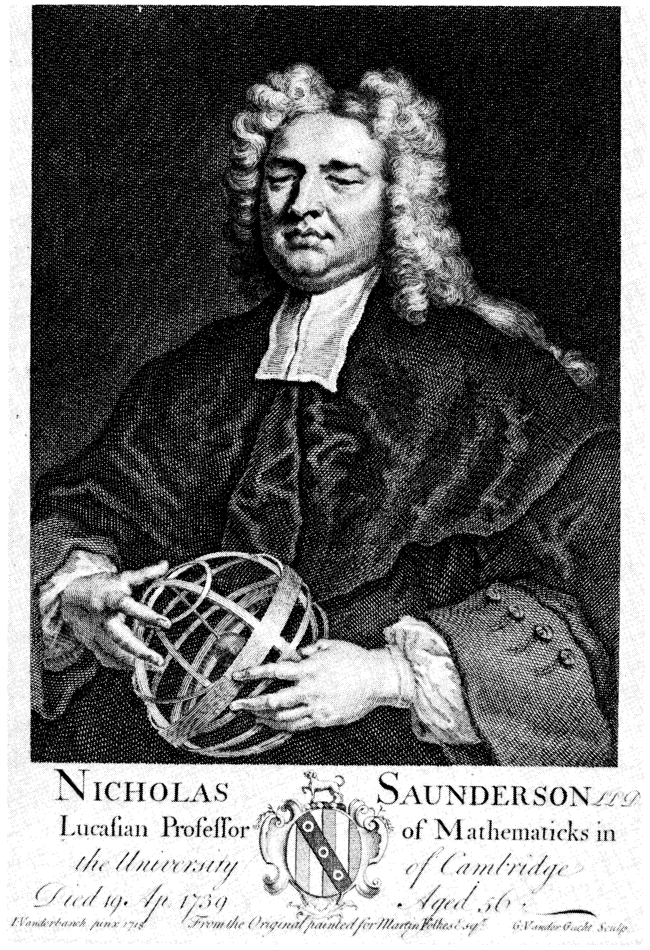

Figure 4. Nicholas Saunderson, From Saunderson (1740).

well known today, though he deserves to be (see Figure 4). He was the fourth Lucasian Professor of Mathematics at Cambridge. Newton had been the second to hold that chair, and in 1711, at the age of 29, Saunderson succeeded Newton's successor. The immediate successor, Whiston, was dismissed in those pretenure days for expressing unwelcome religious views, and Newton had helped settle on Saunderson as the one man worthy of the position. Saunderson was notable for his teaching (he published nothing of note during his lifetime), but his single most remarkable accomplishment was that he succeeded in mastering all of mathematics and natural philosophy despite the fact that he had been totally, irremediably blind from the age of 12 months. In an age when early blindness usually led to neglect and disintegration, Saunderson, despite a relatively humble origin, had risen to the most prestigious chair in England before the age of 30. The French philosopher Diderot was so impressed that he devoted most of one of his early works, his "A Letter on the Blind," to a discussion of Saunderson (see Diderot 1749).

Saunderson lectured on nearly every mathematical topic of the time. Considering his blindness, it is ironical that one of his specialties was optics. He invented a system of calculating that he called "palpable arithmetic" (Schaaf 1981), where numbers were represented by the placement of pins in a board. By stringing thread around the pins, he could represent geometrical figures. He was described as a professor who had not the use of his own eyes, but taught others to use theirs. Saunderson was also known for his frankness, and some accounts of his life hint darkly about licentious behavior.

But it is not enough to note that Saunderson was a remarkable man. If he is to be a true suspect, we need more. We need a strong tie to Hartley, we need a link to De Moivre, and we would particularly like a manuscript containing the gist of Bayes's Theorem (the smoking pistol). And we need to deal with the troubling fact that Saunderson died of scurvy in 1739, 10 years before Hartley's book appeared.

Three of these matters are easy to deal with. Saunderson died early, but Hartley finished his book early. Hartley's *Observations on Man* was begun by 1730 and his correspondence with Lister shows it to have been substantially complete by 1739, and fully finished by 1745. We cannot know when the crucial paragraph was added, but it could easily have come during Saunderson's lifetime. And the link between Hartley and Saunderson was a strong one. They maintained contact after Hartley left Cambridge, and when Saunderson died, Hartley was among the most active in pushing Saunderson's last project to completion. Before he died, Saunderson had been prevailed upon by friends to write a two-volume text on algebra, and Hartley helped sell subscriptions to this, just as he had touted Byrom's shorthand and Mrs. Stephens's cure for stone. Saunderson was *one* of Hartley's ingenious friends; was he *the* ingenious friend?

The link to De Moivre is there. The subscription list to the *Miscellanea Analytica* shows Saunderson's name, right below that of Lady Diana Spencer! The pieces start to fall into place. When De Moivre had completed his first version of his *Doctrine of Chances* in 1711, it was Nicholas Saunderson who had taken the first copy to Cambridge, to Newton's editor and collaborator, Roger Cotes (Cotes wrote, on the occasion, of Saunderson, "he seems to have an extraordinary good genius" (see Rigaud 1841)). A 1740 account of Saunderson's life specifically lists De Moivre as among those "noted mathematicians in London [who] highly esteemed [Saunderson's] friendship, and in deference to his strong reason and judgment, frequently consulted him concerning their writings and designs" (Saunderson 1740).

But where is the smoking pistol? Here I confess to failure. The 1740 account of Saunderson's life tells us something of his tastes and interests: "A proposition must have its uses in order to engage his attention... He considered mathematics as the key to philosophy, as the clue to direct us through the secret labyrinths of nature... There was scarce any part of the mathematics on which our Professor had not wrote something for the use of his pupils." But where are these manuscripts? They were left to "the care and disposal" of John Robartes, the Earl of Radnor, Saunderson's first student. Some manuscripts, on calculus, were published posthumously. Naturally, I launched a search for the remainder. I have learned from Ms. Margaret Sweet of the Royal Commission on Historical Manuscripts that John Robartes died without heirs in July of 1757, a sad month in the history of statistics, and the whereabouts of his papers are unknown. They are not at Cambridge or Oxford. The Bodleian Library at Oxford has sent me copies of the contents pages of some of Saunderson's lecture notes they do hold, but these are not concerned with probability. At my request, George Barnard has visited the University College London library to read a set of notes taken by John West at Saunderson's 1731 lectures on physics, astronomy, and the calendar—lectures that were given after De Moivre's *Miscellanea Analytica* (but before the publication of his limit theorem). They too are a disappointment; they contain no suggestion of probability. D.T. Whiteside, editor of Newton's mathematical papers, knows of no other of Saunderson's papers. Possibly they will still be found, but we must accept for now that they are not available.

Let us then list Saunderson as a prime suspect but not close our minds to other names. In fact, our discovery of Saunderson provides other clues. Hartley was Saunderson's friend, his friend in death as well as in life. After Saunderson died, Hartley exerted himself in obtaining subscriptions to Saunderson's Algebra so that the widow might be supported by the proceeds. Surely the names of all of Hartley's ingenious mathematically inclined friends are on that subscription list. Alas, here too we find too many names, in fact over 600 of them! Should we suspect Charles Feak or William Meeke? Or Mr. Millinent Redhead? Or Sir Benjamin Wrench? The list even included John Michell and a Mr. Nixon (otherwise unidentified), not to mention the great Voltaire! The usual mathematicians (De Moivre, Stirling) are on the list, but—and this may be a telling point—Thomas Bayes is not. The list seems comprehensive, in including any and all potential suspects (other than Saunderson, of course), but the closest to Bayes it comes is a "Rev. Mr. Trubshaw Bates," of Sutterton, Linconshire.

Does this mean we can exonerate Bayes? Not necessarily, for Price does seem to have found a formerly smoking pistol among Bayes's effects. Could not Hartley have encountered Bayes *after* the publication of Saunderson's algebra? After all, Bayes was not elected to the Royal Society until 1742. Indeed, Hartley's correspondence with Lister shows that Hartley spent 10 weeks in Tunbridge Wells in the summer of 1741. But while he mentions some of the people he encountered, Bayes's name is not among them. Indeed, Tunbridge Wells was a thriving spa at that time, and it is quite conceivable Hartley would pass his visit without seeing the quiet Mr. Bayes. The only further light I can cast on that possibility is that in 1741 Hartley's interest in Byrom's shorthand was at a peak (he even prevailed upon the hapless Lister to try it; see Figure 5), but Bayes is known to have used a different system, one due to Elisha Coles (see Figure 6 and Holland 1962). They would effectively have been speaking different languages!

It is time to attempt a resolution. It is time to invite the suspects into the drawingroom for a final scene. These would include Saunderson and Bayes; we could

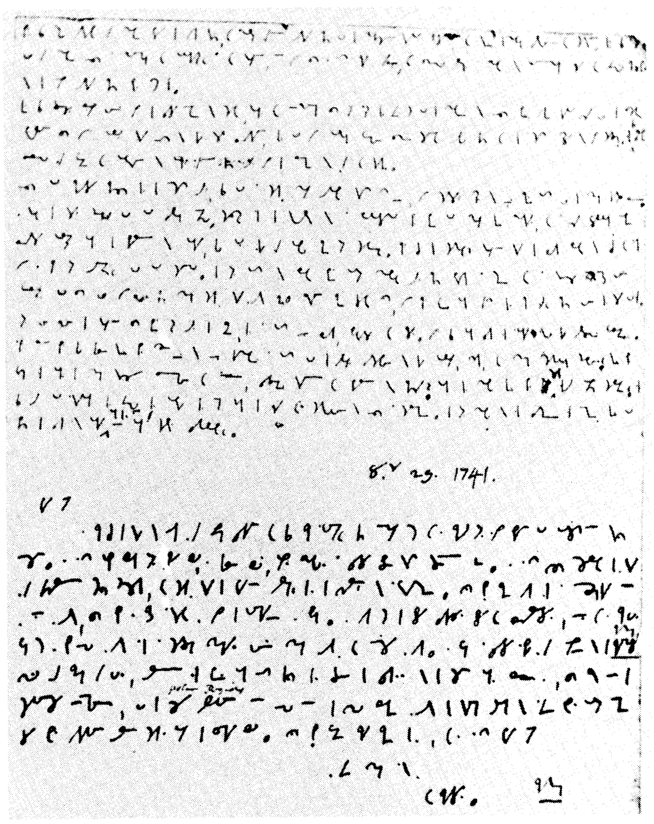

Figure 5. Specimen of Hartley's Shorthand, a Portion of a Letter to Lister Written in Tunbridge Wells in August 1741 (from the Calderdale Archives).

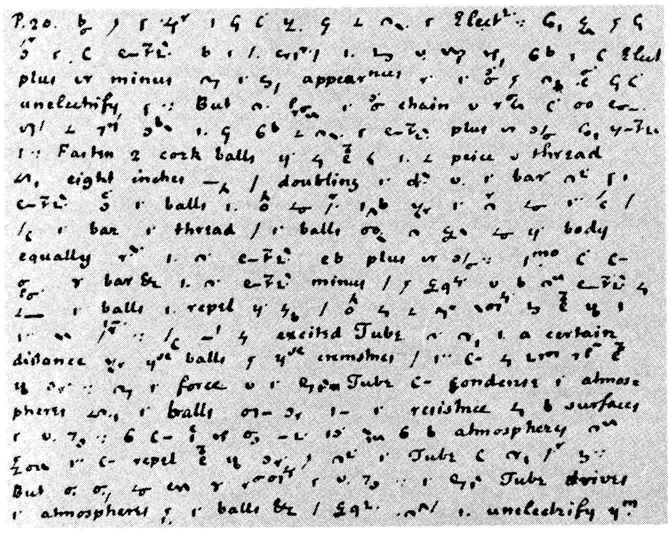

Figure 6. Specimen of Bayes's Shorthand, From Holland (1962).

add several other long shots, but we will settle on the two principals. Now is the time a true detective would reveal a telling piece of evidence, or a brilliant new deduction, followed by a pointed finger of accusation and an emotional confession. Since all our evidence is already on the table, we must try something different. I propose to solve the problem with Bayes's Theorem.

Let us review what we have. Some of the evidence comes from Hartley's published discussion, which tells us that the unknown statistician was Hartley's friend (and, incidentally, that it was not De Moivre). This, and the fact that Saunderson was known to be a friend of Hartley's while Bayes has (to the best of available knowledge) no link to Hartley, favors Saunderson. Further, the mysterious stranger would have surely been inspired to pursue the Theorem by reading De Moivre. Again, we have proof positive that Saunderson subscribed to and knew De Moivre, while Bayes has no such link—further evidence for Saunderson.

What of the fact that both Saunderson and Bayes are known to have been ingenious, Saunderson by the testimony of his friends and Bayes, principally, through the posthumous manuscript found by Richard Price? And of the fact that neither man published the result, despite the fact that whoever the ingenious friend was, he thought the Theorem of sufficient importance to call it to the attention of the nonmathematician Hartley? Here the existence of the manuscript tips the weight in Bayes's favor, but not without some qualms. Saunderson, who died young, had ample reason not to publish, while Bayes (if indeed *he* was the one) maintained silence for 12 years after Hartley's book appeared. We might even be tempted to account for Bayes's silence as due to his discovery, while reading Hartley in 1749 or soon after, that he had been scooped. Or could it be that Bayes got the idea from reading Hartley and the manuscript found by Price was only an attempt to work it through in his own way? We may never know, but let us give Bayes his due.

There remains the possibility that the "ingenious friend" was a third person. Now, many talented mathematicians of the time (including Thomas Simpson, Samuel Clark, William Emerson, Abraham De Moivre, and even Augustus De Morgan's grandfather, James Dodson) can be eliminated on the grounds that they published on probability *after* 1749, and they surely would not have missed the opportunity to state such a marvelous result as their own. Of course, there may still be someone waiting to be discovered, but for now we must settle for Saunderson and Bayes.

Table 1 shows the results of an arduous attempt to assess all this evidence, to boil the totality of our facts and conjectures down to a few simple numbers. The individual probabilities have been constrained by Damon Runyon's rule that nothing in life is more than 3 to 1. And the outcome, treating our major pieces of evidence as approximately independent and taking Laplacian indifference as our a priori opinion, is that Saunderson is favored over Bayes by 3 to 1! This is not enough for conviction, but it suffices for an indictment.

So let us continue to gather evidence, to search the attics of England and the guest registers of Tunbridge Wells. Somewhere, a smoking pistol is waiting. For my part, I plan to resume the search just as soon as I establish the identity of the corpse in Grant's tomb.

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REFERENCES

BYROM, JOHN (1854–1857), *The Private Journal and Literary Remains of John Byrom* (2 vols. of 2 parts each), Ed. Richard Parkinson, In *Remains Historical & Literary Connected With the Palatine Counties of Lancaster and Chester* (vols. 32, 34, 40, and 44), Manchester: Chetham Society.

DE MOIVRE, ABRAHAM (1730), *Miscellanea Analytica,* London: Tonson and Watts.

——— (1738), *The Doctrine of Chances* (2nd ed), London: Woodfall.

DIDEROT, DENIS (1749), *Lettre sur les aveugles,* Translated as "Letter on the Blind" in *Diderot's Early Philosophical Works,* ed. Margaret Jourdain, Chicago: Open Court (1916), 68–141.

HARTLEY, DAVID (1749), *Observations on Man, his Frame, his Duty, and his Expectations,* London: Richardson.

HOLLAND, J.D. (1962), "The Reverend Thomas Bayes, F.R.S. (1702–61)," *Journal of the Royal Statistical Society,* Ser. A, 125,

Table 1. Calculations for a Bayesian [sic] Analysis Showing the Odds are 3 to 1 for Saunderson Over Bayes

	Probability	
Date	*If Saunderson Did It*	*If Bayes Did It*
Saunderson known to be Hartley's friend; Bayes not linked to Hartley	$\frac{3}{4}$	$\frac{1}{4}$
Saunderson linked to De Moivre; Bayes not linked to De Moivre	$\frac{3}{4}$	$\frac{1}{3}$
Both known to be ingenious	$\frac{1}{3}$	$\frac{3}{4}$
Combined (product)	$\frac{3}{16}$	$\frac{1}{16}$

451–461. [Includes a sample of Bayes's shorthand. In a subsequent private letter to C. Eisenhart, Holland has identified the shorthand as Elisha Coles's system.]

MERTON, ROBERT K. (1965), *On the Shoulders of Giants,* New York: Free Press.

PISTORINS, HERMAN ANDREW (1801), *Notes and Additions to Dr. Hartley's Observations of Man . . . to which is prefixed a Sketch of the Life and Character of Dr. Hartley, 3rd Edition,* London: J. Johnson.

RIGAUD, S.P. (1841), *Correspondence of Scientific Men of the Seventeenth Century* (Vol. 1), Oxford: Oxford University Press. [Pages 261–262 include letters from Cotes to Jones concerning Saunderson and De Moivre.]

SAUNDERSON, N. (1740), *The Elements of Algebra,* Cambridge: Cambridge University Press. [Includes an account of Saunderson's life.]

SCHAAF, WILLIAM L. (1981), "The Palpable Arithmetic of Nicholas Saunderson," *Journal of Recreational Mathematics,* 14, 1–3.

SINGER, BERNARD (1979), *Distribution-Free Methods for Non-Parametric Problems: A Classified and Selected Bibliography,* Leicester: British Psychological Society. (Also published in the *British Journal of Mathematical and Statistical Psychology,* 1979, Vol. 32.)

STIGLER, S.M. (1980), "Stigler's Law of Eponymy," *Transactions of the New York Academy of Sciences,* Ser. 2, 39, 147–158 (Merton Festschrift Volume, Ed. T. Gieryn).

——— (1982), "Thomas Bayes's Bayesian Inference," *Journal of the Royal Statistical Society,* Ser. A, 145, 250–258.

TAYLOR E.G.R. (1966). *The Mathematical Practitioners of Hanoverian England, 1714–1840.* Cambridge: Cambridge University Press. (Awful index.)

TRIGG, W.B. (1938), "The Correspondence of Dr. David Hartley and Rev. John Lister," *Transactions of the Halifax Antiquarian Society,* 8, 230–278.

TURNER, J. HORSFALL (compiler) (1883), *Biographia Halifaxiensis, or, Halifax Families and Worthies,* (Vol. I), Bingley: T. Harrison. [Hartley is discussed on pp. 91–93, including his consumption of soap. The account is apparently reprinted from Watson's *Halifax* (1775).]

WALLIS, PETER JOHN (1976), *An Index of British Mathematicians, Part 2, 1701–1760.* University of Newcastle upon Tyne.