

Johann Bernoulli, Man of Contrasts

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1. INTRODUCTION

The Johann Bernoulli lecture is named after the Swiss mathematician Johann Bernoulli, who was 28 years old when, in 1695, the governors of Groningen University invited him to hold the chair of mathematics, which had been vacant for 25 years.

“The conditions were too advantageous to refuse,”

Bernoulli wrote in his autobiography, and he continued

“and so I departed with my wife and our little Nicolas, who was only 7 months old, on the 1st of September of the said year 1695. After having stopped in Holland for a while we continued our journey to Groningen, where we arrived in good health on the 22nd of October.” [7, p. 79]

Bernoulli stayed in Groningen for ten turbulent years, about which I shall not say much today (for a description of this period, see [5]), but then his father-in-law, the influential Basel magistrate Daniel Falkner, put heavy moral pressure on him to return to his hometown Basel. I quote Falkner:

“There is a vacant chair in our academy, which is intended for him, with a rather pretty emolument, and since the good Lord has given him enough means to afford him a respectable life, he would not need to seek his bread in foreign countries, and what’s more, Mons^r his father, who is a man of 80 years, as well as I myself, we would passionately desire to see our Children again, and to have them close to us in our old days.” [6, p. 462]

and this quote is not from a family letter, but from Falkner’s answer to Pieter Burman, the rector of the University of Utrecht. In 1703 Burman wanted to have Bernoulli for the Utrecht chair of mathematics, and the first barrier that he had to pass was Bernoulli’s father-in-law. Bernoulli used the call from Utrecht to improve his conditions at Groningen, where he stayed until, in 1705, he could not longer resist the pressure to return to Basel. The Bernoullis (Johann, his

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wife Dorothea, his nephew Niklaus I, and a nurse who took care of their two sons and two daughters; a third daughter had died when she was only 3 months old) reached Basel on the 27th of September, after a journey of nearly six weeks.

The theme of this introduction is “Johann Bernoulli, man of contrasts”, and it is high time now to paint the announced contrasts. In two broad strokes: Bernoulli was a brilliant mathematician, but his attitude towards colleagues had many dark sides. On the one hand this is not at all surprising, for who does not have at least one unpleasant colleague who plays dirty tricks on him or her? On the other hand there is something strange about it, for why should one play tricks if one could do without? And with his capabilities Bernoulli could certainly have avoided the tricks.

Brilliance and dark sides, let us consider these two aspects of Bernoulli's work and life a bit more closely.

2. BRILLIANCE

Johann Bernoulli's major contribution to mathematics was that he and his elder brother Jakob, from whom he had received his first lessons in mathematics, were the first to really understand the new differential calculus, which Leibniz had introduced in 1684.

The differential calculus, (“a new method for maxima and minima as well as tangents . . .”, as Leibniz called his first publication) is now one of the cornerstones—if not *the* cornerstone—of mathematics, but it had almost made a false start. For Leibniz, who feared criticism against working with infinitely small quantities, had deliberately obscured the ideas upon which his ‘new method’ was based. The 1684 article was only eight pages long, and it contained only the rules for differentiation and some applications. A theory that produces interesting applications, Leibniz seems to have thought, has a better chance to be accepted than a theory with disputable foundations. In 1687 Johann and Jakob hit on the 1684 article, in which Leibniz, as Johann writes

“in 5 or 6 pages gives only a very sketchy idea of the differential Calculus, which was an enigma rather than an explanation; but it was enough for us to get to the bottom of the secret, witness the number of pieces that we published afterwards on the subject of the infinitely small quantities.” [7, p. 72]

But Bernoulli did not stop when he had understood differentiation. Here again are his own words:

“I was the first who thought about inventing some method to restore infinitely small quantities to the finite ones from which these are the elements or differences. I gave to this method the name integral Calculus.” [7, p. 72–73]

And indeed, we owe to Johann Bernoulli the development of the integral calculus as well as the first foundation and further development of the differential calculus. Bernoulli showed, for example, how one should differentiate the exponential function (the absence of such a rule in Leibniz' article had met severe

criticism), and he produced a general theory of integration of rational functions, introducing the method of partial fractions. These were brilliant results, and many more followed. But not only were the results of high quality, the presentation was very good too. Bernoulli's texts and teaching were accessible and inspiring. Two of the most important propagators of the infinitesimal calculus, L'Hospital and Euler, were students of Bernoulli, and the first textbook on differential calculus, the *Analyse des infiniment petits* of L'Hospital (Paris 1696) was directly based on the private lessons that Bernoulli had given to L'Hospital when visiting France in the years 1691/1692. I shall return to this later on.

A last bright side of Bernoulli that I want to mention here is his feeling for posing and solving problems. Famous, of course, is the brachistochrone problem, published in a journal article in 1696 and as a separate sheet in 1697, as a challenge to the mathematical world. The problem led to a whole new branch of mathematics, the calculus of variations. But also as a problem solver Bernoulli earned himself a name. His brilliance was recognized. After Newton's death, in 1727, he was generally considered as the world's leading mathematician.

3. DARK SIDES

Bernoulli had many adversaries, or maybe he felt that he had many adversaries, and at any rate he made himself many adversaries. Some of them I shall mention briefly, about some others I shall say a bit more.

First his brother Jakob, who was 13 years older than Johann and who taught Johann mathematics. Their quarrel started with misunderstandings on both sides, but quickly it exploded into a public dispute, in which either opponent challenged the other, found mistakes in the work of the other, expressed his low opinion of the other not only in private letters but also in journal articles. The documents are available to the modern reader in the beautiful *STREITSCHRIFTEN* [3] volume published by the Bernoulli edition in 1991.

On 16 February 1699 (on the day of the 1993 Bernoulli lecture exactly 294 years ago) both brothers were elected as member of the Paris *Académie des Sciences*, but the Academy made one proviso, which was that the brothers would first cease their struggle and that they would first confirm this to one another.

The next adversary to discuss is also a member of the family: Johann's son Daniel. Daniel, born in Groningen in 1700, is known for his hydrodynamics, for the Bernoulli principle in physics and for the controversy with Euler and D'Alembert about the vibrating string, for which I refer to the Bernoulli lecture by Prof. Zeeman. Daniel wrote several prize winning essays for the Paris *Académie des Sciences*. In 1734 two winners had to share the prize: Daniel and his father. Johann was not happy for Daniel, on the contrary, he was angry with his son. There was an extraordinary large amount of money involved, 5000 pounds. In some of the years the academy awarded a so-called *grand prix*, of 2500 pounds, but a double *grand prix* of 5000 pounds was very exceptional. Johann also falsely predated his article on hydraulics which was partly based

on Daniel's hydrodynamics, so that it would appear that his paper had priority. Johann added thoughts of his own, but it remained plagiarism.

One of the reasons that Johann could not appreciate Daniel's work, was that father and son took different sides in the dispute about who had invented the calculus, Leibniz or Newton, a question which developed into a struggle between the continental and the English mathematicians. Johann took the defence of Leibniz, and Daniel, who was more a physicist, adhered to Newton's ideas. In Bernoulli's view adhering to Newton's ideas was about the worst of all possible heresies.

Brook Taylor, the name-giver of the Taylor Series and an outspoken Newtonian, also had to cope with Bernoulli's attacks. The two communicated via their French friend and colleague Montmor, who passed challenges and solutions to challenges from Switzerland to England and vice versa, and who tactfully did not copy too harsh passages from Bernoulli to Taylor. The conflict is recently documented (in FEIGENBAUM [1], and FEIGENBAUM [2]) and Bernoulli appears there as a chauvinist, someone who is only interested in his own right, and who at one stage even makes a pertinent lie without blinking his eyes.

When Keill, one of the other fighters of the Newtonian case, had died, Bernoulli remarked:

"So Keill is dead? ... His death has caused me to reflect that my aggressors either go mad or die soon after insulting me. ... and Keill has suffered the same fate; who knows what will happen to Mr. Taylor; from what I understand he is no longer robust, his health is tottering and he is an invalid. I hope that he lives and that he repents the wrong he has done to me."

(Letter to Varignon of November 22, 1721; quoted in FEIGENBAUM [2])

Two more cases, and then I shall conclude. First L'Hospital, a profound Leibnizian, by the way. It is clear that L'Hospital has based his textbook *Analyse des infiniment petits* on private information that he had received from Bernoulli. In France Bernoulli gave lessons to L'Hospital. When Bernoulli had left France, the two remained in contact via correspondence. They even made a contract that Bernoulli would continue to inform L'Hospital about his new results, and that L'Hospital would pay Bernoulli in return an annual pension of 300 Pounds (letter of 17 March 1694, [6, p. 202]). In this way L'Hospital bought from Bernoulli the theorem which we now know as L'Hospital's rule. Nothing wrong with that and L'Hospital even, in his preface, says that he owed much to the Bernoulli's, especially to Johann. But when L'Hospital had died, in 1704, Bernoulli tried to be recognized as the real author of L'Hospital *Analyse*. Apparently the mathematical community did not agree with that.

And then poor Giuseppe Verzaglia, from Bologna, who came to Basel to study with Bernoulli, and who was a paying guest in Bernoulli's house for one and a half years. In the end Verzaglia left the house, extremely disappointed, without saying goodbye, and —if what Johann says is true— without paying the customary allowance on departure.

In letters to others Bernoulli threw mud at Verzaglia, whom he called monster, animal, etc. The affair is beautifully documented and described in NAGEL [4].

4. ONE QUESTION REMAINS, AND THAT IS: WHY ALL THIS?

I suggest two connected answers to this question. The first one I take from Nagel who also discusses this question. Johann again and again felt that his priority of a discovery was in danger. And indeed, if we review which mathematical objects now bear his name, we must conclude that he has bad luck. It is true, there are Bernoulli numbers, there is a Bernoulli differential equation, a Bernoulli inequality, and in statistics the Bernoulli experiment, but these are named after Jakob. The Bernoulli principle in physics is named after Daniel. Only the Bernoulli series, which expresses $\int y \, dx$ via partial integration as an infinite sum, is named after Johann, but it is much better known in the equivalent form which expresses y itself as an infinite sum, but then it is called the Taylor series. And last but not least: a possible Bernoulli rule was sold to L'Hospital. Not for sale are the Groningen Bernoulliplein, and of course the Johann Bernoulli lecture. He was right in his opinion that his contributions were of great importance, but he failed to see that diffusion of ideas gave others the right to use these ideas and to elaborate on them. Bernoulli's ideas were like toys: he could not stand that others—with Euler as a special exception—should play with them.

A second suggestion, which is closely connected to the first one, is to look at Bernoulli's personal development. He studied mathematics whereas his father had wanted him to become a merchant. At Basel his brother held the chair of mathematics and therefore for Johann following his vocation implied that he had to leave Basel and to make his money "in foreign countries". This aspect of not being recognized, not being appreciated and supported, this fate of the self-made-man, this ongoing emphasis on money, money, money, can maybe seen best in the following two quotes from letters which Johann Bernoulli wrote from Groningen to his father in Basel. In the first letter, dated 8 November 1695, he asks his father to send money for his younger brother who is visiting him in Groningen. I quote:

"What parents give to their children, they will be refunded a hundred times in their old age. Take us as an example, the other 3 brothers, especially me, for now that I have, without your assistance, succeeded so well in my mathematical studies, how much advancement should I not have had if I would have had some support from you. I am not writing this to extort some money, but merely out of love for my brother." [6, pp. 421–422]

And in a letter of 7 June 1701, in which Johann expresses his happiness that his father has recovered from illness, he writes that he is sad that his father never wrote a letter to him when he was abroad,

"... , except for that one that I received on a previous occasion at Geneva, immediately after my arrival there, where I did not

know my way, or speak the language, and where I felt alone as a lost sheep. And from that letter I hoped to gain some comfort and help, but in which I found nothing but a heart of stone and words that led to despair; you did not even sign your name, up to now I do not know why, and God is my witness. (...)

Why have I never enjoyed so much affection from my father as my other brothers? (...) Please tell me then why they have deserved it more than I: I have behaved me, through God's mercy, so that until today my father has lived to see more honour than shame from me. Where has been in whole Basel and in many years one person who can be proud that his son has climbed to such an honour by his own capacity and without any other recommendation?" [6, pp. 435–436],

In the case of Johann Bernoulli bright and dark did not turn into a pale grey. This peculiar mathematician deserves our attention, in many more introductions to, as I hope, many more Johann Bernoulli lectures.

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