CHAPTER FIVE
THE OFFICER

The eighteenth century was a period of enlightenment throughout the Old and New World. France, the United States, and Poland granted themselves constitutions. Nations were in upheaval as their citizens started demanding equal justice for all, showing concern for human rights, and calling for a regulation of the social order. At the same time, demands for quality government arose and the question of how officials were to be elected to high positions became important again. In this atmosphere two eminent French thinkers appeared on the scene. One was a military officer with numerous distinctions in land and sea battles. His name was Chevalier Jean-Charles de Borda. The other was the nobleman Marquis de Condorcet. The two men, outstanding scientists in Paris during the time of the French Revolution, did something amazing: they reinvented the election methods that Llull and Cusanus had proposed a few hundred years earlier. Actually, they did more than that: they provided the appropriate mathematical underpinnings. At odds with each other on many subjects, they also engaged in a lively debate on the theory of voting and elections.

Born in 1733, Jean-Charles de Borda was the tenth of sixteen children. His parents, both of whose families belonged to the French nobility, were Jean-Antoine de Borda, Seigneur de Labatut, and Marie-Thérèse de la Croix. The boy exhibited great enthusiasm for mathematics and science at an early age and a cousin of his, Jacques-François de Borda, who was in touch with the leading mathematicians of his time, was to point Jean-Charles in the direction of his future career. Jacques-François tutored the boy until, at age seven, he was ready to enter the school of the Barnabite Fathers, whose curriculum was for the most part limited to the teaching of Greek and Latin. Four years later, it was Jacques-François again who convinced Jean-Charles's father to send his son to the Jesuit college of La Flèche, where the offspring of noblemen were educated. It was there, finally, Jean-Charles received a solid grounding in mathematics and the sciences. His achievements were far above average and upon graduation the

Jesuit teachers encouraged the fifteen-year-old boy to enter their order. But Jean-Charles had no interest in religion. He wanted to continue the family tradition and enter the military. The French army provided career opportunities not only for brave fighters but also for intellectuals. Jean-Charles's father allowed his son to follow his own wishes even though he had wanted him to become a magistrate. Thus began Borda's career as an army mathematician.

When Borda was twenty, his first mathematical paper, a piece on geometry, came to the attention of Jean le Rond d'Alembert, the renowned scientist in Paris. Three years later, while serving in the cavalry studying the flight path of artillery shells, Borda presented a theory of projectiles to the Académie des Sciences, whose members elected him to its ranks on the basis of this work.

But his calling still was the army, and the young officer climbed the rungs of the military's hierarchical ladder. As aide-de-camp to the Maréchal de Maillebois, Borda participated in the battle of Hastenbeck in July 1757, where the French army defeated the Duke of Cumberland. But by then he had had enough of horses and decided to exchange the cavalry for the sea. Completing the navy's two-year course in one year he devoted himself to naval construction and to the study of fluids. The navy was suspicious of this "terrestrian" who sought to gain entry into its close-knit officers' corps. Borda managed to prove himself through his academic achievements, however. Taking issue with Newton's theory of fluids for example, he proved that a spherical body offers only half the resistance to airflow than a cylindrical object of the same diameter, and that the resistance increases with the square of the velocity. By advocating spherical shapes, Borda became an early pioneer of submarine and airplane construction. Bodies of this shape would dominate travel under water and in the air—at least until it was discovered that for supersonic flight the most efficient aircraft body has a pointed shape.

The young officer also dealt with more prosaic gadgets like pumps and waterwheels. Throughout his life, Borda participated in many voyages, battles, adventures, and scientific endeavors. For now, we limit the narrative of his achievements to his preoccupation with elections, postponing other parts of his colorful life to the chapter's additional reading section.

The French Revolution, which cost so many of his contemporaries among the nobility, the officer class, and the scientific establishment their lives, left Borda unscathed. He did not participate in any political activity, sitting out the eleven months of the great Terror (September 1793 to July 1794) in his family estate in Dax, a town in the southwest of France. After a long illness, he died in 1799. Many internationally known scientists attended the funeral below Montmartre. His scientific achievements include important advances in experimental physics and engineering, in geodesy, cartography, and other areas.

Staying aloof of political matters during the revolution did not mean that Borda was uninterested in the political process. In fact, it was a sign of the times that one of the areas he dealt with was the theory of voting. In 1770 he had already delivered a lecture about his ideas on a fair election method before the Academy of Sciences. Too busy with military matters at the time, he neglected to publish anything, however. It was only eleven years later, in 1781, that Borda wrote an article titled "Mémoire sur les élections au scrutin" (Essay on ballot elections), which was published in the *Histoire de l'académie royale des sciences* three years later. A preface to Borda's paper, written by an unnamed discussant, lauded it profusely. The introductory essay ended with the sentence that Monsieur de Borda's observations about the inconveniences of election methods that had been nearly universally adopted are very interesting and absolutely new. (The discussant is nowadays believed to be the Marquis de Condorcet, hero of our next chapter.)

In the paper Borda analyzed the well-established method of electing a candidate to a post by majority decision. It seemed obvious to most that this was the correct and fair manner to elect officials. But was it really? Should majority decisions be accepted without question? Borda took issue with the basic, universally accepted axiom that underlies ballot elections, namely that the majority of votes expresses the wish of the electorate.

The axiom seemed reasonable enough and nobody ever made any objection to it. Everybody was convinced that the candidate who obtains the most votes is necessarily preferred to all competitors. It came as a great surprise, therefore, when Borda showed that very often this is not the case. In fact, he maintained that the method of majority elections is unquestionably correct only if no more than two contenders run for a position. If three or more people present their candidacies, Borda pointed out, majority decisions may lead to erroneous results. To make his point, he

presented an example in which a paradoxical situation arises. It is not at all contrived and can easily appear in everyday elections.

I will illustrate Borda's example with the election for class president at a high school. The class comprises twenty-four students. Peter, Paul, and Mary vie for the post; the twenty-one remaining students have to decide among them. Of course they use the age-old method of majority voting. Everyone puts the name of the preferred candidate on a piece of paper and drops the ballot into an urn. The count reveals that eight students voted for Peter, seven for Paul, and the remaining six for Mary. Peter, smiling broadly, thanks the voters for their confidence while Mary, disappointed at her poor showing, leaves the classroom in tears. But is the will of the twenty-one electors truly reflected in this result?

Let us poll the students more deeply about their preferences among all three candidates. The following becomes apparent. The eight students who put Peter first, would have put Mary second and Paul last. The seven who voted for Paul would also have put Mary second and relegated Peter to the end of the list. Finally, Mary's six supporters would have placed Peter behind Paul. The complete list of preferences can be summarized in the following table (where "preferred to" is indicated by " > "):

8 electors:	Peter > Mary > Paul
7 electors:	Paul > Mary > Peter
6 electors:	Mary > Paul > Peter

If we now scrutinize the preferences, we realize that in direct showdowns as advocated by Ramon Llull (see chapter 3), both Mary and Paul would have beaten Peter by thirteen votes against eight. (The seven electors in the second line of the table, and the six electors in the third line, place Peter behind both Paul and Mary.) So Peter, the undisputed winner of the majority vote, would already be out of the race. A comparison of the voters' preferences between Mary and Paul would then reveal that fourteen classmates (those in the first line and those in the third line) would have voted for her, and only seven for Paul. Now the shoe is definitely on the other foot: Mary wins, and Peter surreptitiously wipes away a tear. The results are the exact reverse of the ones obtained by majority election.

The simple explanation for this paradoxical situation is that the support Peter receives from eight electors is more than offset by the utter rejection of his candidacy by thirteen others who place him dead last. The paradox had gone unnoticed for centuries because once an election was over, nobody ever bothered to compare the voters' preferences among the losers. There will be more to say about this paradox in the next chapter.

In one fell swoop Borda challenged an election method that had been used throughout the world for centuries. The example shows that different outcomes may occur as soon as voters become more farsighted and take into account the preferences beyond their first choice. Borda compared the situation to a sporting event in which three athletes vie for the title. After two competitors have worn themselves out in a first bout, both of them, by then tired and exhausted, may succumb to a weaker opponent.

But the navy officer did not simply criticize the age-old method, he also proposed a remedy. He called it "*Éléction par ordre de mérite*" (Election by ranking of merit). It would lead to a great debate between two outstanding French intellectuals of the eighteenth century.

In Borda's proposed voting method every elector jots down the names of the candidates in the order of merit he accords them. The ranking could be, for example, Peter on top, then Paul, then Mary. Borda proposed awarding one merit-unit—let's call it an *m-unit* for short—to each rank. Mary at the low end would get one, Paul two, and Peter three. If more candidates are present, the count would go higher. For eight candidates, the bottom-ranked candidate receives one m-unit, the top-ranked candidate eight.

This manner of awarding m-units rests on an assumption, however. Borda maintains that the degree of superiority the elector accords Peter over Paul is the same as the superiority of Paul over Mary. This assumption needs a justification and Borda provides it by employing some hand waving: since there is no reason to rank Paul (the middle candidate) closer to Peter than to Mary, the correct method would be to place him smack in the middle between them. So, given Borda's belief that the difference in merit between all ranks is identical, it is quite reasonable to award one additional m-unit to the next-higher rank. Of course, many people would dispute this assumption. The *intensities* with which electors prefer one candidate over another may differ.

Now on to the next stage. Peter in the above example was ranked first by eight, and last by thirteen electors. In Borda's manner of reckoning

Peter would therefore obtain 37 m-units ($[8 \times 3] + [13 \times 1]$). Paul would receive 41 ($[8 \times 1] + [7 \times 3] + [6 \times 2]$) and Mary a whopping 48 ($[8 \times 2] + [7 \times 2] + [6 \times 3]$). Now we understand why Mary should win. By the way, this manner of adding m-units also rests on an assumption: electors are considered to be equal. Then m-units awarded by different electors have the same value and can be summed. (Many people would dispute this assumption also. After all, my m-units may be different from yours.)

The astute reader may have recognized in Borda's count of m-units the method from the previous chapter, put forth by Cardinal Cusanus. The French navy officer was not aware of his predecessor. Indeed, the Cardinal's proposals for the election of popes and emperors were quite unknown during Borda's times and only rediscovered in the late twentieth century. But Borda would have provided an advance even if the earlier writings had been known to him. While Cusanus had implicitly assumed that one additional rank—be it from rank fifteen to fourteen, or from rank two to one—should always accord the candidate the same additional gain, Borda made the assumption explicit and gave it a justification. Granted, it was a hand-waving justification, but a justification it was nonetheless. The method suggested by the cardinal and by the navy officer, of choosing among candidates by assigning points, or m-units, according to their standing in the electors' rankings, is nowadays known as the Borda count.

Borda's and Cusanus's assumption that each additional rank is worth the same is crucial. Without it, several variations of the method can be thought of. The Eurovision song contest, mentioned in chapter 4, is a case in point. There, no m-units are awarded to the worst songs. Then one m-unit is given to the song ranked eleventh, and one additional m-unit is awarded for each rank up to the second-best song, which receives ten. Finally, the best song in a jury's opinion receives twelve m-units. Different variants of the method could be thought of, and they may result in different winners.

After presenting his method of voting "by order of merit," Borda went on to analyze under what circumstances the winner according to his scheme would coincide with the winner in a majority election. How many votes would a candidate need to receive in a conventional majority election so that he would also be guaranteed the top spot according to the rules of the Borda count? Let us say that Peter and Mary are ranked in first place by a and b electors, respectively. Borda investigates the worst-case scenario from Peter's viewpoint. Such a situation occurs if all of Peter's supporters put Mary second on their list, but Mary's supporters place Peter last.

a electors:	Peter > Mary > Paul
b electors:	Mary > Paul > Peter

In this case, Peter receives $3a$ m-units from his supporters and b m-units from Mary's fans, who placed him last. Mary receives $3b$ m-units from her supporters, and another $2a$ m-units from Peter's voters who placed her second. In order for Peter to get elected by the Borda count, the number of m-units he is awarded ($3a + b$) must be greater than Mary's m-units ($3b + 2a$). Note now that $a + b = n$, the number of voters. Simple arithmetic then shows that Peter must garner at least two-thirds of the votes in a conventional majority election in order to guarantee his win according to the Borda count.

More generally, if there are n candidates, the winning candidate must receive at least $1 - 1/n$ parts of the votes cast in a simple majority election to be certain that he would have won even by the Borda count. (I derive this simple result in the mathematical appendix to this chapter.) In the case of two candidates that means receiving at least half the votes, which is the same as saying that a simple majority suffices. This makes sense. But a line-up of, say, five candidates would require a candidate to receive four-fifths, or 80 percent, of the votes to make him the undisputed winner of both election methods. This may seem overly stringent and it is. Most often less support suffices because the worst-case scenario usually does not arise.

An interesting case appears when there are more candidates than there are electors. In order for a candidate to obtain the threshold of $1 - 1/n$ parts of the votes, there must be at least n electors. If there are less than n electors, unanimity among the electors is required. (If there are six candidates but only five electors, the winner would have to receive at least five-sixth of the votes. This means he needs to obtain all five votes.)

There are problems with the Borda count, some minor, some major. One of the minor ones is that draws may occur. Borda did not express himself on what should be done if two candidates receive the same number of m-units. It may have been obvious to him that a runoff election would decide between the two. What if three or more candidates receive

the same number of m-units? A second election by order of merit would be called for, and so on. And what about the case when an elector cannot rank two or more candidates because he is indifferent between them? Let us say there are five candidates and the elector ranked the first and second candidates, but is indifferent about the next three. Should they all receive three m-units, or one m-unit, or something in between?

A more serious problem is that, paradoxically, the winner of the Borda count may be nobody's favorite. It is easy to conjure up election results in which a candidate wins even though she is ranked no more than second best by all electors. For example:

11 electors:	Paul > Mary > John > Peter
10 electors:	Peter > Mary > John > Paul
9 electors:	John > Mary > Peter > Paul

Paul would get 63 m-units ([11 × 4] + [19 × 1]), Peter 69 ([11 × 1] + [10 × 4] + [9 × 2]), John 78 ([21 × 2] + [9 × 4]) and Mary, who is neither liked nor hated by anybody, would get 90 and win (30 × 3). The ranking would be Mary > John > Peter > Paul. By the way, a simple majority election would have given the ranking Paul (11 votes) > Peter (10) > John (9) > Mary (zero), the exact opposite of the Borda count.

Another paradoxical situation may arise through the sudden appearance of a clearly inferior candidate. Even though he would be ranked low on every voter's list, his addition to the roster may have a non-negligible influence on the election's outcome: the Borda counts of the front-ranked candidates could be changed, pushing a different winner forward. Let us assume that 51 electors prefer Ginger to Fred, and 49 prefer Fred to Ginger:

51 electors:	Ginger > Fred
49 electors:	Fred > Ginger

The Borda count declares Ginger the winner with 151 m-units ([51 × 2] + [49 × 1]), and Fred 149 ([51 × 1] + [49 × 2]). Now Bozo appears on the scene. Nobody really likes Bozo but his entry persuaded three of Fred's voters to rank Ginger even behind Bozo:

51 electors:	Ginger > Fred > Bozo
46 electors:	Fred > Ginger > Bozo
3 electors:	Fred > Bozo > Ginger

Now Ginger receives 248 m-units, Fred 249, and Bozo 102. Bozo's entry caused Fred to win.

Hence, by adding a dunce to the roster, the winner could be changed. The same may happen if a candidate drops out of the race or—may Heaven forbid—dies before the actual voting takes place. The most important challenge to the Borda count, however, is that it is open to manipulation through so-called strategic voting. This is the problem Pliny the Younger had been wrestling with (see chapter 2). We will have more to say about this practice in chapter 12.

Borda's suggestion was widely discussed in Paris. And the difficulties did not go unnoticed. Then another luminary appeared on the scene. His name was Marie-Jean-Antoine Nicolas de Caritat, Marquis de Condorcet.

BIOGRAPHICAL APPENDIX

Chevalier Jean-Charles de Borda

During several crossings of the Atlantic, Borda had the task of testing marine chronometers and studying methods to calculate the longitude of the ship's position. Toward the end of the eighteenth century, these were questions of paramount importance for maritime navigation. The latitude of a ship's position, that is, the distance north or south of the equator, can be ascertained relatively simply with the aid of a sextant or octant. Since these measurements are not affected by the earth's rotation, latitudinal positions can be determined by measuring angles of, say, the sun at noon over the horizon. Measurement of the longitude, though, is affected by the earth's rotation. Hence, a boat's east–west position cannot be established so easily. In order to ascertain the longitudinal position, a precise clock was needed that showed—wherever on the globe one may be—the local time at a reference point. Then, by comparing the reference time with the time at the current location, the ship's longitudinal position could be calculated. For example, if the sun at the current location is at its midday position and the clock, keeping the time of Le Havre, shows two o'clock in the afternoon, the navigator gathers that his ship is two hours, or 30 degrees, west of the port. (Twenty-four hours correspond to the full circle, that is, to 360 degrees. Hence, every hour's difference is equivalent to 15 degrees, which, along the equator is about 1,600 kilometers.) Together with the already determined latitude, the vessel's exact position on the globe is known. The clock's movement needed to be very precise, however. A deviation of just five minutes from the correct time at the reference point could translate into an error of up to 140 kilometers

east or west. Many maritime disasters could have been avoided had exact timing devices been available to the ships' captains.

Pendulum clocks were of no use at sea, of course. They were meant to be hung on stable walls, not placed on vessels heaving and wallowing about in rough sea scapes. Watchmakers from various countries tried to invent timekeeping devices that would function sufficiently well even under extreme circumstances, but none were successful until the Swiss watchmaker Ferdinand Berthoud came to the rescue. He invented an isochronous balance wheel, driven by a spring that winds and unwinds at constant speed, which kept exact time even on boats rolling in foul weather. A first experiment showed that even after ten weeks of continuous operation the clock had accumulated an error of no more than one minute. In order to further test Berthoud's timepiece, King Louis XV ordered the mounting of an expedition. De Borda was appointed scientist in charge of the tests on board the *Flore*. The results exceeded the most optimistic expectations. After completion of the trip he and the ship's master composed a report titled "*Voyage fait par ordre du roi, en 1768 et 1769, dans différentes parties du monde, pour éprouver en mer les horloges de Monsieur Ferdinand Berthoud*" (Voyage undertaken by order of the king in 1768 and 1769 to different parts of the world in order to test the clocks of Mr. Ferdinand Berthoud at sea). The report was read to great acclaim at the Academy of Sciences. Berthoud was appointed the King's master watchmaker and awarded a yearly pension of 10,000 francs.

During the American war of independence Borda was promoted to captain and put in charge of a vessel. Cruising in the Caribbean and along the American coast on board the *Seine* he participated in many exploits. In the famed Battle of the Saints, in 1782, six ships were under his command. It was to be the end of his career at sea, however. The British enemy proved stronger and after several hours of battle—his vessel disabled and a large part of his crew killed—Borda was taken prisoner. He was lucky, though. His captivity was not very severe and did not last very long. Upon his liberation he returned to France and was named director of the Engineering School of the French navy.

Only then did Borda, who was already fifty years old, start his second career as a scientist. It was to immortalize his name to a far greater extent than would his military exploits. At that time, great confusion reigned in all parts of France. Merchants, traders, and shopkeepers in every province and in every town used different weights and measures—which sometimes carried the same name. The confusion made commerce extremely difficult. In 1790 King Louis XVI set up a commission to study how the units could be standardized. Half a year earlier, the tentative proposal had been made to base measurements of lengths on the pendulum. The unit of measurement was to equal the length of the pendulum whose swing back and forth lasts exactly one second. The method seemed acceptable to Britain and the United

States, and French scientists were quite enthusiastic about the fact that their proposal was about to gain international approval. A proposal was submitted to the National Assembly, which referred it to the Committee on Agriculture and Commerce, which recommended it to King Louis XVI, who passed it on to the Académie des Sciences, which established a committee to further study the matter. Now things got into high gear. The blue-ribbon committee consisted of Paris's most celebrated scientists: Jean-Louis Lagrange, Pierre-Simon Laplace, Gaspard Monge, the foremost mathematicians of their time; Antoine Lavoisier, the great chemist; and the Marquis de Condorcet, mathematician, politician, and economist of whom we will read much more in the next chapter. Jean-Charles de Borda was named the commission's president.

The commission saw a few problems with the pendulum; for one, they felt that basing one unit of measurement (length) on another (time) was not an appropriate approach. After all, the division of the day into 86,400 seconds was artificial and could be changed at any time. In fact, Borda advocated dividing the day into 10 hours of 100 minutes each, the latter being made up of 100 seconds. The second problem was even more serious; since the earth is flattened at the poles the gravitational constant, which is responsible for the swing times, is not identical everywhere. Hence, at different places on earth, different lengths of pendulums are needed to produce a one-second swing. This problem could have been rectified by determining a specific place on earth where the pendulum would be timed and measured, but such a decision would have challenged the national pride of all countries who—it was hoped—would adopt the new system. Another reason to reject the pendulum was that time appears as a squared term in the equation that determines the period of its swing. The scientists wanted to keep everything simple and linear.

So another solution was sought. In the committee's first report, of October 1790, the members decided to adopt a decimal division of money, weights, and measures. Actually, the subdivision of units had not really been the issue, but the scientists found it nonetheless important to address the question, presumably because it was so convenient to use the ten fingers to count off the digits. This report was a prequel to their second report, of March 1791, in which the committee announced its decision to define the unit of length as the 10 millionths part of the quarter meridian, that is 0.0000001 of the distance from the North Pole to the equator. All that now remained was to measure this distance . . .

And this is where the real difficulties started. Measuring the earth in the late eighteenth century was a task comparable to building a space station in our days. The French scientists were not easily intimidated, however, and set themselves to the task. To facilitate the enormous undertaking, Borda invented a device that allowed the measurement of angles to a precision unheard of in his time. With this tool, measurements could be made by triangulating the landscape, and distances could be

computed using trigonometry. But then the committee became aware of another difficulty; nobody had ever set foot on the North Pole, let alone measured any distance emanating from it. The scientists bypassed this problem by deciding to make do with the distance between Dunkirk and Barcelona. Measuring the distance between these two towns, establishing their latitudinal positions, and taking into consideration the earth's flattening at the North Pole, the total length of the quarter meridian could be computed.

But the revolution interfered. France was at war, the Republic was established, Louis XIV was tried and put to death, the Terror took over, Lavoisier was executed, Condorcet committed suicide or was murdered, the Academy was abolished. In short, confusion reigned. In the midst of all this, the scientists went about carrying out their task. One team of surveyors made its way south from Dunkirk—with their poles and flags and measuring devices—while another team worked northward from Barcelona over the Pyrenees. The members of the teams were arrested numerous times. More than once did they escape death only narrowly by pointing out that they were working on a replacement for the hated royal measuring system. Undeterred by all the hardships, they continued with their task until they met at the town of Rodez, about 500 kilometers south of Paris.

The undertaking had lasted nearly eight years. On November 28, 1798 the committee announced that the ten millionth part of the distance between the North Pole and the equator corresponded to 0.513243 *toises*, or, as we are wont to say nowadays, to one meter. Along with the liter and the gram, the meter became the official unit of measurement through a law enacted on December 10, 1799. Recent measurements, performed with the help of satellites, show that the French surveyors' measurement of the distance between Dunkirk and Barcelona was off by only about the length of two football fields. Thus, the meter that they had established more than two centuries ago was correct to within one-fifth of a millimeter.

MATHEMATICAL APPENDIX

Borda Count and Majority Elections

Let us assume that there are n candidates and E electors. a electors rank Peter first. If a is greater than 50 percent, Peter would be elected by the majority. Under which circumstances would he also be guaranteed victory by Borda's method?

In Peter's worst-case scenario, Mary would be ranked second by the a electors who ranked him first, and first by everybody else, that is, by $E - a$ electors. Peter would be ranked last by $E - a$ electors:

a electors:	Peter > Mary > . . . . . .
$E - a$ electors:	Mary > . . . . . . > Peter

Peter would receive n m-units from each of the a electors who rank him first, and 1 m-unit from all others, for a total of $a \times n + (E - a) \times 1$. Mary would receive $n - 1$ m-units from the a fans of Peter, and n m-units from all other electors, for a total of $a \times (n - 1) + (E - a) \times n$.

For Peter's m-units to be greater than Mary's the following inequality must hold:

$$a \times n + (E - a) \times 1 > a \times (n - 1) + (E - a) \times n$$

Solving this, we obtain,

$$a/E > (n - 1)/n = 1 - 1/n$$

The term on the left-hand side, a/E, is the proportion of electors who place Peter first. If this proportion is greater than the right-hand side, $1 - 1/n$, Peter is guaranteed victory by the Borda count, even in the worst possible scenario.

CHAPTER SIX
THE MARQUIS

Scholarly debate in the French capital, with its newspapers, publishing houses, academies, and *salon* tradition, was always very lively. It was no different with Borda's voting scheme. As could be expected, his proposal of assigning points, or m-units, to preferences did not go unchallenged. The challenger came in the form of a nobleman, who was Borda's junior by ten years. His full name was Marie-Jean-Antoine Nicolas de Caritat, Marquis de Condorcet.

Born in 1743 in Ribemont, Condorcet was the only child of an ancient family of minor nobility. His father, a cavalry captain, was killed during a military exercise when Condorcet was only five weeks old. His mother, a fanatically religious woman, raised her son without any education. As a sign of devotion to the Virgin Mary and to the boy's childlike innocence, he was forced to wear white dresses until he was nine years old. This, his mother hoped, would guarantee her and her son's eternal salvation.

But then his uncle, a bishop, took over. Religion and devotion were all right, but even this man of the church thought this was going a bit too far. He hired a tutor so the boy could catch up with others his age, and then sent him to a Jesuit school in Reims, in the northern part of the country. Even though Jesuit schools were considered the best educational system Europe had to offer, they did not provide what one would nowadays consider a positive environment. Learning by rote and corporal punishment were the main instruments of instruction. Furthermore, rampant homosexuality among the monks and students left Condorcet with a hatred of the church that lasted throughout his lifetime. Nevertheless, he received a first-class education.

The boy's exceptional intellectual gifts soon became apparent and his uncle had him sent to the Collège de Navarre in Paris to continue his studies. In the first year, the college's program consisted of studies in philosophy, which Condorcet deeply disliked, and in the second of mathematics, at which he excelled. During his studies he had the good fortune of meet-