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He no doubt recognized that his discovery of a use for measures of variability was of major consequence, and he described the moment of insight with a scene that brings to mind Newton's apple tree:

> As these lines are being written, the circumstances under which I first clearly grasped the important generalization that the laws of Heredity were solely concerned with deviations expressed in statistical units, are vividly recalled to my memory. It was in the grounds of Naworth Castle, where an invitation had been given to ramble freely. A temporary shower drove me to seek refuge in a reddish recess in the rock by the side of the pathway. There the idea flashed across me, and I forgot everything else for a moment in my great delight.[4]

Applications of Galton's "important generalization" go far beyond z-scores and t-scores. Without the ability to measure variability, and to use that index to specify an individual's standing in a group, we would have to end statistics at this point. Correlation, regression, and most inferential statistics require a means of specifying an individual's place in a group independently of the original units of measurement.

[1]The probable error is very similar to our modern standard deviation; the standard deviation was brought into general use by Karl Pearson in the 1890's.

[2]From Galton's Anthropometric Laboratory, Notes and Memoirs, No. 1, quoted in Karl Pearson, The Life, Letters and Labours of Francis Galton (Cambridge: Cambridge University Press, 1924), II, 384-385.

[3]Sir Francis Galton, Memories of My Life, 3d ed. (London: Methuen, 1909), p. 298.

[4]Ibid., p. 300.

Understanding and Using Statistics-Basic Concepts, Marty J. Schmidt, pp. 116-117.

The Normal Curve

The Normal Distribution

The normal curve that is so familiar in modern statistics was known among early-nineteenth-century mathematicians as the Law of Error--a term that describes its first practical applications in science.[1]

Astronomers of the 1830s were greatly concerned with errors. Mathematical theorems had been developed that predicted the orbits of various heavenly bodies very precisely, but theory could not always be advanced or verified through the telescope because human error entered into every observation. Differences in observers' reaction times and minute variations in spatial judgments from observation to observation added a personal equation to every measurement, one that had to be circumvented if possible. Thus, astronomers turned to mathematicians like Pierre La Place and Karl Gauss for detailed descriptions of errors. These men, perhaps more than any others, laid the foundation for modern statistics by pointing out that errors are distributed as a normal curve (although the term normal curve did not come into use until several decades later) and that the probabilities associated with different error sized can be predicted from a knowledge of the curve. This made it possible to predict the "most probable orbit" of heavenly bodies from a number of observations.

Sir Francis Galton, however, should receive primary credit for pointing out that the Law of Error also describes a multitude of biological and psychological distributions. Making the bridge between mathematics and biology, Galton wrote in Natural Inheritance:

> I need hardly remind the reader that the Law of Error upon which these Normal Values are based, was excogitated for the use of astronomers and others who are concerned with extreme accuracy of measurement, and without the slightest idea until the time of Quetelet that they might be applicable to human measures. But Errors, Differences, Deviations, Divergencies, Dispersions, and Individual Variations, all spring from the same kind causes . . . . The Law of Error finds a footing wherever the individual peculiarities are wholly due to the combined influence of a multitude of "accidents". . . . All persons conversant with statistics are aware that this supposition brings Variability within the grasp of the laws of Chance, with the result that the relative frequency of Deviations of different amounts admist of being calculated, when these amounts are measured in terms of any self-contained unit of variability.[2]

Galton was fully aware that using the mathematical abstraction to describe real distributions required an ultimately unprovable assumption, namely, that the underlying characteristic was normally distributed; he was also aware that many naturally occurring distributions are not normal in shape. He made it clear, however, that he believed the assumption of normality justified, in some cases, even if not provable:

> It has been objected to some of my former work, especially in Hereditary Genius, that I pushed the applications of the Law of Frequency of Error somewhat too far. I may have done so, rather by incautious phrases than in reality; but I am sure that with the evidence now before me, the applicability of that law is more than justified. . . . I am satisfied to claim that the Normal Law is a fair average representation of the Observed Curves during nine tenths of their course . . . the agreement of the Curve of Stature with the Normal Curve is very fair, and forms the mainstay of my inquiry into the laws of Natural Inheritance. It has already been said that mathematicians laboured at the Law of Error for one set of purposes, and we are entering into the fruits of their labours for another.[3]

[1]Abraham DeMoivre published the equation for the curve in 1733, but it saw little practical application for nearly 100 years. Those interested in a more complete history of the normal curve -- and of many other methods treated in statistics -- should see Helen M. Walker's classic, Studies in the History of the Statistical Method (Baltimore: Williams and Wilkins Co., 1929).

[2]Sir Francis Galton, Natural Inheritance (London: Macmillan and Co., 1894), pp. 54,55.

[3]Ibid., pp. 56, 57.