STATISTICS

What Can We Predict?

Probability theory founded on a gambler's curiosity has become an essential part of almost every field of study and important to every man.

By RUBY YOSHIOKA

➤ A MATHEMATICAL SYSTEM which was born in order to predict the probable winnings of gamblers is now helping man predict the path of atomic particles, the color of a hybrid flower, the odds against quintuplets or whether an eel will swim to America or to Europe.

Aside from gambling, our daily lives are full of probabilities. Will it rain? Will I pass the science exam? Will a surgical operation be successful? At best what we decide will or will not happen is based on some previous experience or just a guess as to the outcome or a "feeling" of what probably will take place. This is the common conception of probability.

But for mathematicians and statisticians, probability is more than a guess or intuition. They have devised mathematical systems, some of which are very complex, whereby the chances of an event occurring can be predicted.

How Theory Arose

The theory of mathematical probability arose from the studies of games of chance, early in the 17th century. Blaise Pascal, a French mathematician, scientist, and philosopher, and creator of the famous Pascal triangle based on the binomial theorem, was asked by a gambler friend, who was interested in the "why" of gambling chances, to figure out why certain odds were more favorable to a gambling house than other odds. This Pascal undertook with the help of Pierre Fermat, another French mathematician, and developed probability theory.

Since that time, probability theory has become increasingly important and many mathematicians have contributed to its advancement.

Probability theory today has applications in virtually every field from atomic physics and biology to social science.

Predictions of weather, population increase, the number of accidents that may occur during a holiday weekend and the probable outcome of elections are all examples of the application of mathematical probability, as are the estimation of insurance rates.

The classic example to explain probability theory is in tossing coins. If a coin is flipped, what is the chance that it will turn up heads? Since it must turn up either heads or tails, the probability is 1/2; in 100 throws the probability is 50 heads and 50 tails in an ideal situation.

This does not mean that if heads shows in the first throw, tails will turn up in the next. Each throw is independent of the previous throw, since coins do not have a memory. However, in the long run, that is, after many tosses, say 100,000, the ratio of heads to tails tends to be 1 to 1.

Thus, if in 100 throws, there are 45 heads, heads could turn up about 450 times in 1,000 throws. It would be most unusual and highly improbable that in 1,000 throws the number of heads would be only 45. Actually tossing the coin and recording the result would show this to be true.

Taking another example, if a die is thrown, the chances of any one of the numbers, 1 through 6, appearing is 1/6. This means that after many throws, or in the long run, any single number, say 3, will appear in 1/6 of the throws.

If you throw two dice, one blue and one white, the chance of 3 appearing on a blue die is 1/6 x 1/6 or 1/36, and on a white die it is also 1/36, but a sum of 3 can be produced in two ways, with a 2 and 1, both equally likely. Thus its probability is 2/36, or 1/18, so a sum of 3 may be expected to occur once in every 18 throws.

As the number of throws increases, the chances of occurring at this ratio increase.

More Complex Problems

These simple applications of probability theory as shown in the tossed coins and the throwing of dice have been applied to more complex problems of probability. James Bernoulli, later in the 17th century, clearly defined probability theory in relationship to large numbers of cases, applying the same mathematical equation.

As a result of Bernoulli's law and subsequent related laws, the central limit theorems were derived. These theorems state that as the number of trials increases, the predictions made by probability theory can be more and more closely satisfied.

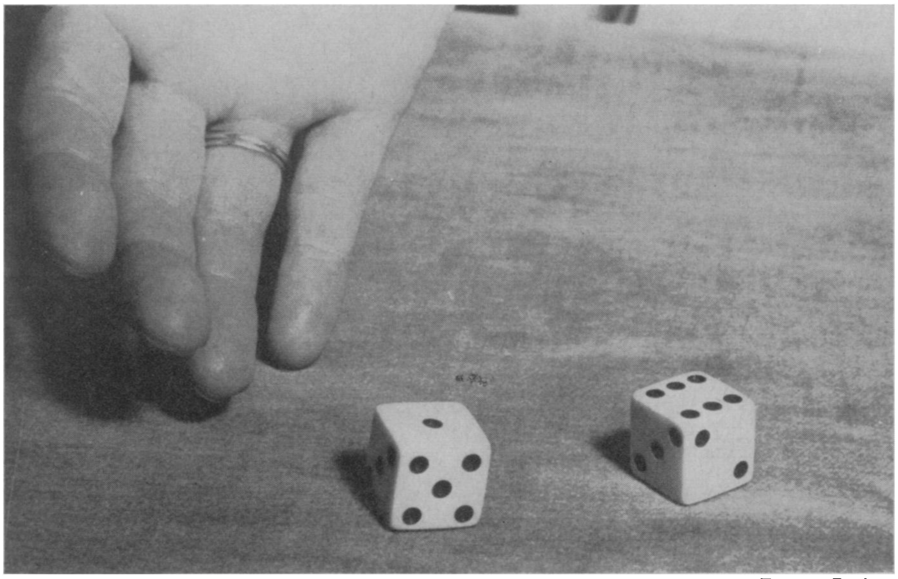
For example, taking coins again, the ratio of heads to tails tends to come closer to 1 to 1 as the number of throws is increased. However, an interesting point is that the actual numerical difference between heads and tails tends to become greater with the greater number of trials. In 100 throws, if tails show 45 times and heads 55 times, the difference is 10. But, if 1,000 throws are made and the ratio is 450 to 550, the numerical difference is 100.

Why Gamblers Lose

Thus, the best lesson a gambler can learn from probability theory is that if he continues to play, he will always lose. Mathematicians have shown, since the time of Bernoulli, that the chances of loss become greater and greater as the gambler continues to play and the resources of the house increase compared to those of the gambler.

This is also true in a slot machine. The more quarters a player puts into the machine, the slimmer become his chances of becoming a winner.

A curve can be drawn from a table of the various ways in which an event may happen, such as the tossing of coins. The probability distribution curve is bell-shaped and is known as the normal distribution curve, or Gaussian curve after Karl Friedrich Gauss.



Fremont Davis

WIN, LOSE OR DRAW—Rolling dice, one of the oldest games of chance, still persists despite the teachings of mathematical probability.

The normal curve is used extensively in many applications, for example, in showing the variations of I.Q. in a certain age group or the heights of different races. Where natural phenomena can be measured, such as the number of peas in a pod or the weight of children of a certain age, the normal probability distribution is closely followed.

In genetics, the Mendelian theory of the transmission of traits can be predicted by probability theory.

If a red flower is crossed with a white flower, the red gene will unite with the white gene to form a pink flower. If two pink flowers are then crossed, the next generation will produce one red, one white and two pinks, following the pattern of the probability distribution of heads and tails when two coins are tossed.

This ability to predict offspring of plants is most useful to agriculturists and botanists in hybridizing and improving plants and animals.

Random Sampling

It is often desirable to know how a population will vote or how well a machine is turning out a product. A system of random sampling has been devised.

The straw vote taken before an election is an example of random sampling. From such a vote, the trend of the election can be predicted.

If the product of a new machine is to be tested, samples selected at random can give the manufacturer an indication of the quality of the whole.

Sampling is a convenient and oftentimes the only method by which a study of large groups can be made.

In physics the behavior of atoms and molecules and the paths of electrons and protons are determined probablistically. Since it is impossible to determine the exact position or exact motion of an electron at a particular moment, its position or direction of movement must be based on probability and must be estimated.

Most physicists believe that probability behavior governing electrons must also apply to the universe, but the late Prof. Albert Einstein, among other scientists, believed there is an underlying order in the universe that does not involve probability.

Astronomers apply probability statistics when determining the position of stars and space sicentists calculate travels in outer space on a probabilistic basis.

New Method of Calculation

A new method of calculating probability that uses only existing factors rather than previous events has been recently devised by Prof. Marcel Neuts of Purdue University, Lafayette, Ind.

Prof. Neuts reported that his method can be applied to actual biological and physical phenomena as well as purely theoretical mathematical problems.

The concept of mathematical probability is far reaching and enters into virtually all phases of our lives, from birth rates to death rates, with all the probabilities and statistics that can happen in between.

Since this is so, an early introduction to the concept of probability and statistical methods would be extremely valuable to students in almost every field of study. To help make this important step in the introduction of probability theory to younger students, SCIENCE SERVICE has issued a THINGS of science kit on probability containing problems and explanations of elementary mathematical probability and the materials necessary to perform the experiments. The unit is available at 75¢ each from SCIENCE SERVICE, Washington, D. C. 20036.

• Science News Letter, 85:138 Feb. 29, 1964

TECHNOLOGY

Highway Safety Studied

➤ A MECHANICAL "YO-YO" and a machine that shocks drivers who take risks are among many devices being used to study highway safety at Ohio State University, Columbus.

The yo-yo consists of a reel of steel cable attached to the front on one car and running to the rear of another car. It records the relative speeds of the two cars and the distance between them on the highway, thus enabling engineers to learn what influences one car following another.

Another device, called a risk simulator, tests drivers with many traffic violations and those without any to see why some drivers take risks on the road. At certain intervals, the subject passes his hand about 10 inches through a small window, taps a switch and tries to remove his hand before being hit by a rotating arm that gives him a sharp electric shock.

Each time he completes the risk before being shocked, the "driver" receives a certain amount of money. In another part of this study, a "passenger" receives a shock at the same time as the subject, thus indicating if drivers behave differently when they have passengers.

One result from early studies showed the non-violator group took the same number of risks whether alone or with a partner. The violator group, however, took fewer chances when with a partner.

A driver's ability to judge speed is being determined by velocity sensing tests. Subjects drive without speedometers and are supposed to reach different speeds. Most of these preliminary tests have shown that drivers are unable to judge the rate of speed accurately. Their judgments vary between 10 miles per hour too fast or too slow.

The effects of highway lighting on drivers are being studied by special instruments in test vehicles that measure the amount of glare striking the driver's eyes and the windshield.

• Science News Letter, 85:139 Feb. 29, 1964

TECHNOLOGY

Classroom Computers, TV Replace Blackboard

➤ COMPUTERS and closed circuit television are putting the traditional blackboard out of a job.

Instead of burning the midnight oil over an engineering problem involving a great deal of computation, students can reach a solution quickly on the classroom computer.

At the Massachusetts Institute of Technology's department of civil engineering, Boston, the automated classroom minus blackboards is a reality. College freshmen, after a single session with the specialized computer languages, are ready to design highway interchanges using the machines to perform their computations.

• Science News Letter, 85:139 Feb. 29, 1964

General Dynamics/Electronics

HAND-HELD RADAR—The hand-held radar system detects moving targets and warns a military observer by means of audio signals through earphones.

TECHNOLOGY

Hand-Held Radar Device Spots Nearby Movement

➤ A NEW self-powered radar unit, carried in the hand, can detect any moving object up to six-tenths of a mile away.

The eight-pound unit and antenna detect targets and warn the operator by signals through earphones or over a small loudspeaker on the rear of the unit.

Developed by General Dynamics/Electronics, San Diego, Calif., the new radar can be used by soldiers for spotting enemy movements in foggy or wooded areas. Soldiers also can contact low-flying friendly aircraft with it.

The new radar also can be used by border patrols, police and factory guards. Developers expect improved wiring will lighten future versions even more.

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