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Mathematical and Statistical Probability As a Test of Circumstantial Evidence

Thomas H. Liddle III

Mr. Liddle feels that one of the main problems engendered by science for the law involves the utility of probability theory to the law of evidence. The author’s contention is that the difficulty has arisen as a direct result of the law’s misapplication of probability theory. Thus, following a brief introduction to the mathematical theory, he traces its use in the courts, showing that probability itself is no stranger to law as witness the devices of judicial notice and legal presumptions. The argument is then conclusively made that probability theory does have utility in law, but that its greatest use is in that area where a number of past events may rationally bear on the probability of the occurrence of a future event. Even then, however, the selection of variables and the assigning of odds to each variable remain perplexing problems. The author concludes that variables should be selected by lawyers, as they have the knowledge best suited to determining relevancy, but that odds should be assigned by scientific experts. Courts should be cautious, but not afraid, in using probability theory, for, if properly applied, it can be of great value in the truth-determining process.

I. INTRODUCTION

Law and science were once allies; they parted ways, and perhaps now the two disciplines are seeking to draw closer together again. Indeed, Professor Cowan has suggested that, if the mountain of technology will not come to the law, perhaps the law should consider going to the technological mountain.1

On a less philosophical level, we know that there are certain scientific or technical disciplines that can be and have been applied to the law.2

It is the purpose of this article to suggest one scientific discipline that may be applied to law and to call attention to the fact that this particular technology — mathe-

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2 See, e.g., Kort, Simultaneous Equations and Boolean Algebra in the Analysis of Judicial Decisions, 28 Law & Contemp. Prob. 145 (1963). Professor Cowan also discusses some of the applications of sophisticated scientific methods to the decision-making process which are of particular interest to the lawyer. A generous bibliography is included. Cowan, supra note 1.
PROBABILITY AND EVIDENCE

I. BACKGROUND

A. Mathematical Probability

Probability may be expressed as a percentage (10 percent, 50 percent, 99 percent) or as odds (10 to 1 against, or 3 to 2 for) or as a fraction or decimal (1/2, 0.5). No matter how it is expressed, it represents the proportion that favorable events and unfavorable events bear to each other and to the total number of events. Thus,

\[ P(A) = \frac{m}{n} \]

where \( m \) is the number of ways the event \( A \) may occur and \( n \) is the total number of events.

Example 1: The probability that one toss of a coin will result in a head, since either of two possible events (head or tail) is equally likely to occur, is:

\[ \frac{1}{2} \]

Example 2: In rolling a pair of dice once, what is the probability that the sum of the face numbers will be 7? Since there are two devices (two dice) and each device has six possible faces, the total number of chances is \( 6^2 = 36 \). Because the favorable event may occur in six different ways \( (1,6), (2,5), (3,4), (4,3), (5,2), (6,1) \),

\[ P = \frac{6}{36} = \frac{1}{6} \]

We may also express this as the sum of several products. If we consider each die separately and each favorable event separately, the probability that face number (1) will appear on one roll of die \( 1 \) is \( \frac{1}{6} \), and the probability that face number (6) will appear on one roll of die \( 2 \) is \( \frac{1}{6} \). The probability that the simultaneous roll of die \( 1 \) and die \( 2 \) will yield (1) and (6) respectively is given by the product of their separate probabilities:

\[ \frac{1}{6} \times \frac{1}{6} = \frac{1}{36} \]

Example 3: What is the probability of rolling 6 or 8 in one roll of a pair of dice?

For (6):

\[ P(6) = \frac{5}{36} \]

For (8):

\[ P(8) = \frac{5}{36} \]

Let \( P_6 \) denote the probability of a single roll of 6, and \( P_8 \) denote the probability of a single roll of 8. Then:

\[ P_6 = P(6) + P(8) = \frac{5}{18} \]

(c) Conditional probability, or the probability of the successive occurrence of two events \( A_1 \) and \( A_2 \), is given by the product of the unconditional probability of event \( A_1 \) and the conditional probability of event \( A_2 \) which assumes the occurrence of \( A_1 \).

\[ P(A_1, A_2) = P(A_1) \times P(A_2 | A_1) \]

Example: A box contains seven balls — three red, four black. If two balls are selected at random from the box, what is the probability that they will both be black? Let \( P_R \) denote the probability of drawing first one black ball, and \( P_B \) denote the conditional probability...
if a coin is tossed there is one chance of a head and one of a tail, and each chance is equally likely to occur. Hence the chance of a tail may be expressed as 1/2, 50 percent, 0.50, or "even money."

The probability of obtaining two tails in two tosses is given by the product of the probabilities of each toss, and may be calculated by multiplying the fractions or decimal expressions of the probability. Thus the probability of getting two tails in two tosses is

\[ \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} \]

or 25 percent. The odds against are 3 to 1, .75, 3/4, or 75 percent. In the fractional or decimal system, absolute certainty or a "no unfavorable events" condition is one, and minimum probability or "no favorable events" is zero.

More generally, if we consider two events, \( A_1 \) and \( A_2 \), one may be interested in knowing whether both \( A_1 \) and \( A_2 \) will occur simultaneously or successively. The joint event will be denoted by the product of the individual probabilities of events \( A_1 \) and \( A_2 \). On the other hand, one may be interested in knowing whether at least one of the events \( A_1 \) and \( A_2 \) will occur. This event will be denoted by the sum of the individual probabilities of \( A_1 \) and \( A_2 \). At least one of the two events will occur if \( A_1 \) occurs but \( A_2 \) does not, or if \( A_2 \) occurs but \( A_1 \) does not, or if both \( A_1 \) and \( A_2 \) occur.

Thus, the probability of drawing second another black ball: \( P_{bb} = \frac{4}{7} \). After drawing the first black ball, three remain, thus:

\[ P_{bb} = (P_{b1}) \times (P_{b2}) = \left( \frac{1}{2} \right) \times \left( \frac{1}{3} \right) = \frac{1}{6}. \]

The probability of any number \( n \) of successive tails is expressed as \( (0.5)^n \). See note 3 supra.

\[ P_{bb} = \frac{3}{6} \]

P. HOEL, INTRODUCTION TO MATHEMATICAL STATISTICS §§ 2.2-2.10, at 4-18 (2d ed. 1954).

4 See note 3 (c) supra.

5 The probability of tails on three successive tosses is determined by the general expression: The probability of event \( A \) taken \( n \) times is \( (P_A)^n \).

\[ (0.5)^3 = 0.125. \]

The probability of any number \( n \) of successive tails is expressed as \( (0.5)^n \). See note 3 supra.

6 P. HOEL, supra note 3, § 2.5, at 7.

7 Id.
probability of having either heads or tails on one toss of a coin is 0.5 + 0.5 = 1. It is a certainty.

B. Probability in the Courts — Some Illustrative Cases

As a starting point for examining the relationship of mathematical probability to the judicial process, a brief survey of several early cases of note may be helpful.

In People v. Risley, the defendant was prosecuted for offering into evidence at an earlier trial a typewritten document, which he allegedly knew had been fraudulently altered by the insertion of the two words "the same." At the trial the State offered as an expert witness a university professor of mathematics. He testified that the probability of the same defects found in the six letters allegedly inserted in the document (which corresponded to the defects in the same six letters when typed on a machine owned by the defendant) appearing in a typewriter other than the one which actually typed the words was one in 4 billion. This figure was deduced by multiplying together the separate probabilities that each of the individual defects would occur independently. The Court of Appeals of New York ruled that the expert's testimony was erroneously admitted into evidence, and reversed the conviction. The finding of error was based first on a lack of qualification by the witness as an expert in typewriting and second on the fact that he did not take into consideration the effect of the human operation of the machine.

Some writers have supported the Risley holding as justified on the ground that the witness did not know enough about typewriters to accurately assign to each particular defect the odds against its appearance. The criticism was not of the selection of factors — the defects — nor of the application itself of the rule of compound probability.

Example 2: A box contains two white and four black balls. What is the probability of selecting one of each color on two successive draws? The first draw is independent and may occur in one of two ways (white or black); but once the first choice is made, the second depends upon it in order to meet the conditions set — one white, one black.

If black is drawn first, \[ P = \frac{2}{3} \times \frac{2}{5} = \frac{4}{15}. \] If white is drawn first, \[ P = \frac{1}{3} \times \frac{4}{5} = \frac{4}{15}. \] Since events \( A_1 \) (first draw) and \( A_2 \) (second draw) are not mutually exclusive, we use the multiplication theorem of note 3(c) supra, and not the addition theorem of note 3(b) supra.


\( 9 \) Based on the law of compound probability. This law provides that the probability, \( P \), of the simultaneous occurrence of independent events \( A_1, A_2, A_3 \ldots A_n \) is given by the product of their separate probabilities. Thus

\[ P = (P_1) (P_2) (P_3) \ldots (P_n). \]

P. Hoel, supra note 3, §§ 2.6, 2.7, at 8-10.

\( 10 \) E.g., C. McCormick, Evidence § 171 (1954).
probability to the odds against each defect. However, the following remarks of Justice Seabury, dissenting in Risley, seem more persuasive:

Common sense at once recognizes how remote is the probability that all of these defects should recur in these six identical letters in any other typewriter. Indeed, if the district attorney, basing his argument upon matters of common knowledge and the general perception of all men, had pointed out that there was not one chance in four thousand millions that these identical defects would be found in these identical six letters of another typewriter, he would, I think, have been within his rights. Substantially the same statement did not become prejudicial because it is made by one learned in the higher mathematics.¹¹

It would seem that the Court of Appeals of New York was mistaken in its basis for finding error in the admission of the expert testimony. One writer stated: "The obvious though unsound objection to the admission of such evidence [as in the Risley case] is that it is an opinion by a witness no more expert in the sort of phenomena under investigation — typewriters — than the jury."¹²

But was the expert testifying as to his opinion concerning typewriters, or was the subject a mathematical postulate applied to certain known and determinable and undisputed facts about the machine? It is fundamental to the law of evidence that one possessing special skill or knowledge concerning the sort of phenomena under investigation, and whose opinion will therefore be of assistance, will be permitted to express an opinion as to the probability of an occurrence.¹³ It seems equally in accord with the spirit of the "opinion rule" to allow the same sort of testimony by one who, although without special knowledge of facts, is skilled in the specialized method of treating the facts, provided his method is of value.¹⁴

It should be parenthetically pointed out that the court was misinformed if it meant to suggest anything other than that an added variable in the form of the human operation would increase the probability against such a duplication of defects in another typewriter.¹⁵

In a case decided prior to Risley, the Supreme Court of Utah discussed the same identification problem concerning typewriter

¹⁴ Id. § 1923.
¹⁵ See P. HOEL, supra note 3.
defects, but did not assign numerical values to the probability of the occurrence of the separate defects. The defendant had sworn to certain affidavits which were filed in the case. The State sought to show that typewritten letters received by the prosecuting witness were typed on the same typewriter as defendant's affidavits, by showing that it was highly unlikely that two machines would have the same defects. An expert testified that, while it might be possible for two machines to have precisely the same defects and to produce the same faulty printing in every respect that characterized the letters and affidavit, such a coincidence is not at all probable. The testimony was held to be admissible.

The famous Howland Will Case, certain facts of which are reported in an earlier account of another trial of the same case, Robinson v. Mandell, is cited in the Risley opinion. Professor Benjamin Pierce of Harvard College, a noted mathematician, discussed the mathematical implications of the case: "In the case of Sylvia Ann Howland this phenomena [that two signatures of the same person made at different times could be identical in every respect unless one was copied over the other] could occur only once in the number of times expressed by the 30th power of 5 or $2666 \times 10^{19}$..."

Plaintiff's counsel, however, had shown that, of 110 copies of President John Quincy Adams' signature, 12 could be superimposed upon one another. He had also shown a remarkable similarity among a number of signatures of several other witnesses. While this does not allow the inference that Sylvia Ann Howland's signature had the same similarity, it would certainly tend to reduce the probability against one exactly duplicating his own signature at some later time. The point should be noted, and will later be examined in detail, that the crucial issue involves the assigning of initial odds to each separate event, rather than in the use of the conditional probability theory to predict a result.

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16 State v. Freshwater, 30 Utah 442, 85 P. 447 (1906).
17 Id. at 445, 85 P. at 449.
18 The Howland Will Case, 4 Am. L. Rev. 625 (1870).
19 20 F. Cas. 1027 (No. 11, 959) (C.C.D. Mass. 1868).
20 The Howland Will Case, 4 Am. L. Rev. 625, 649 (1870). It should be noted that the 30th power of 5 is $931 \times 10^{19}$.
21 Text accompanying notes 63 & 64 infra.
22 See section VII infra.
III. THE LEGAL PROBABILITY SPECTRUM

Now that we have seen the form in which mathematical probability theory appears in the legal process, it is in order to consider the extent to which it is recognized and accepted by the courts in the context of legal standards. This may be best appreciated by visualizing a spectrum of "probability" running from conclusiveness to uncertainty.

A. Judicial Notice

Courts have dealt with and have allowed juries to deal with predictions and probability estimates of future events based on frequency statistics. Mortality tables, as one of the bases for predicting length of life, are an example.\(^2\)

Mortality or actuarial tables showing the probable continuance of the life of a person at different ages, as distinguished from the duration of the ability to earn money or perform work, have been regarded as impartial and disinterested and so nearly in the nature of an exact science or mathematical demonstration as to be credible and valuable. The Supreme Court recognized this as long ago as 1898.\(^4\) There seems to be little doubt that mortality tables are admissible as evidence of the life expectancy of a person where such a determination is in issue.\(^5\) The tables are used so frequently that most courts have taken judicial notice of their validity without requiring authentication.\(^6\)

It has been recognized in a number of cases that the testimony of an actuary or mathematician is admissible on the question of the present value of the permanent loss or impairment of earning capacity.\(^7\) Similarly the testimony of actuaries or mathematicians has

\(^2\) See, e.g., Pollack v. Pollack, 39 S.W.2d 853 (Tex. App. Comm. 1931). A promised to pay B $5000 per year for the rest of B's life, upon condition that, if A predeceased B, the payment would cease and A would devise $100,000 to B. A breached; B sued for the full value of A's promises. The court employed an actuarial table to calculate the probability of the contingency, and determined that A's life expectancy was 11.67 years.


\(^6\) Immel, Actuarial Tables and Damage Awards, 19 Ohio St. L.J. 240, 245 n.17 (1958).

been admitted in evidence on the question of the present value of pecuniary loss in wrongful death actions.\textsuperscript{28}

The scientific method, as embodied in actuarial tables based on statistical verification, blood tests based on biological verification, and fingerprints based on physiological verification, reveals empirical verification of a probability approaching certainty. To the scientist, although perhaps not yet to the lawyer, these methods produce such a high degree of uniformity and reproducibility of results that he can make predictions and identifications that may be taken as certain or conclusive.\textsuperscript{29}

It is well established that evidence as to the correspondence of fingerprints is admissible at the trial of a cause to prove identity.\textsuperscript{30} Although blood tests should also be included at this end of the probability spectrum,\textsuperscript{31} not all jurisdictions have accorded conclusiveness to blood test results showing nonpaternity. The New York courts seem to hold the exclusionary blood test to be conclusive evidence of nonpaternity when the jury believes that the test was performed correctly.\textsuperscript{32} This position is quite similar to that taken by a New Jersey court in \textit{Cortese v. Cortese}.\textsuperscript{33} Although many States consider such evidence admissible but not conclusive,\textsuperscript{34} New Jersey is one of a growing list of jurisdictions which either by statute or judicial decision accord conclusive weight to blood grouping test results which exclude paternity.\textsuperscript{35}

It is clear that not all States give conclusive weight to blood tests in appropriate cases, and thus one may suggest that the inclusion of such tests at this end of the spectrum is somewhat suspect.

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\textsuperscript{29} See C. McCormick, \textit{supra} note 10, § 171, at 364.

\textsuperscript{30} See Annot., 63 A.L.R. 1324 (1929).


\textsuperscript{33} 10 N.J. Super. 152, 76 A.2d 117 (App. Div. 1950). The court observed that blood tests cannot always prove paternity, but can disprove it conclusively in a great many cases provided that they are administered by qualified experts. \textit{Id.} at 156, 76 A.2d at 119, \textit{citing} Beach v. Beach, 114 F.2d 479, 480 (D.C. Cir. 1940).

\textsuperscript{34} 1 J. Wigmore, \textit{supra} note 13, §§ 165(a)-(b).

\textsuperscript{35} At least six States have adopted the \textit{Uniform Act on Blood Tests to Determine Paternity}, which recognizes the conclusiveness of blood tests to establish non-paternity. Note, \textit{supra} note 31, at 203, 205 n.28.
However, rejection by the courts of evidence which reaches nearly maximum certainty as a matter of mathematical probability must surely be bewildering to nonlegal folk. It is highly doubtful that much of the evidence routinely admitted by all courts reaches that degree of certainty.

The argument, then, is for judicial acceptance as conclusive of blood tests whose results approach maximum certainty as a matter of mathematical probability. The chance that a putative father will be excluded by blood tests when in fact he is the father is 1/10,000. This is the biological certainty. The position that such tests should be conclusive is based on the presupposition that the evidential reliability (legal certainty) is equal to the biological certainty. If every woman giving birth came before a judge and he adopted the rule of accepting the mother’s declaration when it agreed with the blood test and otherwise rejecting it, he would give a correct decision in 9999 out of 10,000 cases. Here the legal certainty equals the biological certainty. But if the judge decides only those cases in which the mother’s testimony is contrary to the blood tests, the question becomes whether the judge would give a correct decision in 9999 out of 10,000 cases if he were to follow the same rule, i.e., excluding the mother’s claim when it contradicts the blood test results. There is no reason to believe that the exceptions to the biological rule would occur in the same proportion (1 in 10,000) within that narrower area which represents legal action, unless the area were selected in a way unrelated to parentage, such as by drawing lots, and not through the mother’s testimony.

Professor Ross suggests that, if we take a sample of 100,000 births, 10 exceptions, and 100 cases which under our hypothesis of conflicting testimony and test results lead to legal action, the question becomes whether the distribution of the exceptions between the 100 cases and the 99,900 consistent situations is in the same proportion as the biological certainty (1 in 10,000). He argues that the legal certainty will be less than the biological certainty, although still high enough to be given conclusive effect, because it is dependent upon (1) the number of legal actions in relation to the

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36 See authorities cited note 31 supra.
37 Ross, supra note 31, at 471.
38 Id. at 472.
39 Id. at 473-74.
40 Id. at 475.
number of possible exceptions and (2) the average truthfulness of
mothers.\footnote{Id.}

B. Presumptions

At the next level in the hierarchy of judicial conclusiveness are
found legal presumptions. The operation of presumptions, and
their ultimate dependence for their validity upon mathematical prin-
ciples, is best illustrated by the familiar "intoxication statutes."

There are several tests used to determine intoxication in motor
vehicle violations, including the chemical analysis of blood, urine,
breath, or other bodily substances, all of which give rise to presum-
tions. Medical science has established that it is not the amount of
alcohol consumed by the person that affects his driving ability, but
rather the amount of alcohol absorbed into his blood and thus cir-
culated to his brain and central nervous system.\footnote{Note, Evidence: Scientific Devices: Use of Chemical Tests for Determining Intoxication, 1 U.C.L.A. L. Rev. 610, 611 & n.10 (1954). A typical statute provides the following test results as giving rise to presumptions: "(1) less than .05\% by weight of alcohol in the blood — not under the influence; (2) at least .05\% but less than .15\% — no presumption either way; (3) .15\% or over — presumed under the influence." Id. at 612 n.11. The writer discusses the extent to which judicial notice is taken of these test results as fact.}

Many State legislatures have adopted rebuttable presumptive
statutory standards for intoxication which are admissible provided
the test is given within a prescribed time and administered by com-
petent personnel.\footnote{C. O'HARA & J. OSTERBERG, INTRODUCTION TO CRIMINALISTICS 349 (1949); C. MCCORMICK, supra note 10, \S 176.} In McKay v. State\footnote{235 S.W.2d 173 (Tex. Crim. App. 1950).} a Texas court refused to
adopt such a test for what seems to be the wrong reason. The court
based its rejection on a challenge of the accuracy of such tests to
establish the alcohol content of a subject's blood. It would seem
obvious even to the layman that a court is not competent to chal-
lenge the empirical test results of so elementary a scientific determi-
nation as the one in question.

A more reasonable and valid criticism is the reliability of the
premise on which the presumption is based. Surely a court would
be correct in questioning the premise that medical science has con-
clusively established that an alcohol content in the blood of more
than 0.15 percent constitutes absolute intoxication without regard
to the subject. In order to test this premise, sound mathematical
probability theory would require actual experimentation upon a
sufficiently large sampling of human subjects. Even then, some margin for statistical error, however small, would remain. It is, therefore, the mathematical translation of the test results into a legal conclusion that is subject to question, not the test results themselves.

C. Probability as a Test for Predictability and Identification

Judicial notice and legal presumptions involve the introduction into evidence of data whose reliability is attested to by the scientific method of factfinding — unemotional, objective, controlled, and impartial. Such data has a quality of predictability, certainty, or, if you will, "probability," which is translatable into numerical values and approaches a magnitude which the mathematician or scientist would accept as conclusive. Blood type tests, fingerprints, and actuarial tables are examples of such data. Because of their reliability and certainty, we may predict a pattern of future events based upon a large number of past events using actuarial tables, ascertain specific facts about past events using blood type tests (where the biological error is 1 in 10,000), and make highly certain identifications regarding past events using fingerprint data.

Further along the spectrum is the use of compound probability theory to find or identify facts about past events, based on the notion that it is highly unlikely that any fact or event other than the one proposed would satisfy all of the given conditions. Thus, for example, an identification may be sought to be established by isolating individual characteristics or conditions and assigning odds corresponding to their occurrence or frequency of appearance in a given system. The odds either favoring or against their individual occurrence are not so high as to provide any reliable basis for identification, but taken collectively, the odds rise rapidly against all of them occurring again, in the same combination, in another event.

An extreme use of this application of the laws of mathematical probability is found in a recent criminal case in San Pedro, California. A woman was mugged; a witness saw a blonde, ponytailed girl run out of an alley, enter a yellow car driven by a bearded Negro, and speed away. The prosecutor at the trial invoked a test of circumstantial evidence based on the laws of statistical probability. After an expert witness testified as to the mathematical calculation of the probability that a set of events will occur at once, the prosecutor asked the jury to consider the six known factors in the case: (1) a blonde white woman, (2) a ponytail hairdo, (3) a
bearded man, (4) a Negro man, (5) a yellow car, and (6) an interracial couple. He assigned probability factors ranging from 4-to-1 odds that a girl in San Pedro would be blonde to 1000-to-1 odds that the couple would be interracial. Multiplied together, the factors produced odds of 1 in 12 million that this couple could have been duplicated in San Pedro on the morning of the crime. They were convicted by the jury of second-degree robbery.

While it may seem at once apparent to the reader that this analysis of circumstances is highly questionable, it is submitted that its fault lies not with probability theory itself, but rather in its misapplication. The precise nature of this misapplication will be examined shortly.

D. Uncertainty

The previous discussions considered identification and factfinding about past events, where the factfinder had as a starting point some basic knowledge of the events. At the lower end of the probability spectrum, the consideration turns to future contingent events — events that would or might have occurred but for the intervention of some other event. Here the attempt is made to assign some numerical value to the probability that the future event would have occurred.

An example is to be found in the area of damages for lost expectations, where two rules are frequently applied. One is the "all-or-nothing" rule, whereby the plaintiff will win all that he would have received if the event favorable to him had occurred, provided his expectation expressed mathematically is greater than 50 percent; if it is less than 50 percent plaintiff wins nothing. The other is the simple mathematical probability theory, whereby plaintiff receives exactly the value of his expectation that the event would have been favorable to him — that is, an amount proportionate to his chance of winning.

46 See note 9 supra.
48 This is the majority rule in the United States. See C. McCormick, DAMAGES § 31 (1935).
49 This is the prevailing rule in England. Mayne & McGregor, DAMAGES 170-74 (12th ed. 1961). To illustrate the two rules, assume a box containing seven bills, four $1 bills and three $10 bills. If a contestant is permitted to draw one bill and keep it after payment of a certain fee, what is the expectation and possible damages, aside from
In *United Shoe Workers v. Brooks Shoe Manufacturing Co.*\(^{50}\), a suit by a union against an employer for breach of contract, the court adopted the rather novel view that the damages should be based on the value of plaintiff's interest in the possibility of future contracts with the defendant, as distinguished from the traditional "lost profits" measure of damages in breach of a sales contract. The damages awarded to the union represented future union dues calculated on the prospective existence of a union contract for a given number of years. It is not clear which test the court used, since it awarded damages on the basis of the existing rate of union dues and the actual yearly loss to the union at present rates projected over a 20-year minimum life expectancy of the company. This is not really a determination of the present value of the chance that the contract would run for 20 years and might suggest that the court was awarding the "all" of the "all-or-nothing" test. However, although the court did not indicate that the probability of the union's obtaining future contracts exceeded 50 percent, it did talk in terms of probable loss and observed that there was a considerable difference between possibility and probability.

Applying either approach to this case, the reliability of the value of the damages is limited by the accuracy of assigning a numerical value to the probability that future contracts would have been made. The utility and reliability of any application of mathematical probability rests on two factors: first, identifying the factors or variables and second, assigning probability values to them. As expressed by one writer commenting on this case:

The probability that two given parties would have made a future contract had not one party severed the relationship is the sum of the probable non-occurrence of all the facts that could prevent the contract. To predict whether future contracts would have materialized, the court must first determine which factors not to consider. If it considered all of the facts that persuaded the employer to abandon the Union in the first place, the probability would have been zero and no damages awarded. In deciding what factors to exclude, the court has two alternatives: (1) to exclude out-of-pocket losses of the fee, if he is not permitted to make a drawing? Intuitively his expectation will be equal to the fee charged for playing the game. The probability of drawing a $1 bill is 4/7 and a $10 bill is 3/7. Expectation under the simple probability theory is determined by multiplying the mathematical probability that the future event will be favorable by the full value of the future gain if it is favorable. The total expectation is \( E = (4/7 \times $1) + (3/7 \times $10) = $4.86 \). However, under the "all-or-nothing" rule, since the probability of winning one $10 bill is less than 50 percent (3/7), plaintiff receives no $10 bill but since the probability of winning a $1 bill exceeds 50 percent (4/7), plaintiff will not receive 4/7 \times $1 = 0.57 as above but the full $1.

all the factors that the employer would use in deciding to end the relation; or (2) to use the bad faith of the employer as a standard. Still the court would be hard pressed to identify all of the factors that could preclude future contracts even under alternative (1) let alone to assign numerical values to the probability of each occurring.

. . . .

Nation-wide or industry-wide statistics may report the number of times some facts have occurred in the past, and this data may be projected into the future. But factors that may prevent two given parties from making future contracts do not exist independent [sic] of each other. When the probability of one reaches a certain level, the probability of others may increase or decrease; and the statistical method cannot measure this interaction in a specific factual complex. Many relevant factors themselves are largely products of individual attitudes and company policies. 51

A similar problem is faced in wrongful death actions involving loss of future earnings. Assuming that it is more probable than not that future employment would have materialized, then under the "all-or-nothing" method the plaintiff in such an action might receive damages in an amount equal to the sum of the deceased's projected earnings over a life expectancy based on actuarial tables. Under the probability theory, recovery would be had for the loss of the chance that the employment would have continued (the sum of the earnings for the life expectancy multiplied by the probability that future employment would materialize). A court would face the same nearly impossible task of assigning a numerical value to that probability. 52

Courts have taken opposite views as to the degree of the probability of expectation of receiving rewards for the capture of alleged criminals. In Smithe v. Gentry 53 the plaintiffs followed a suspected criminal for whose capture a reward was offered by the State. Becoming convinced of the criminal's identity, they telephoned the defendant, who they mistakenly believed to be a constable. The defendant obtained the information, captured the criminal, and received the reward. The court held that the plaintiffs could not recover the reward from the defendant, since their damages were too remote — their injury was only the loss of a naked possibility.

In McPeek v. Western Union Telegraph Co., 54 the wife of a suspected murderer agreed to telegraph the plaintiff when she knew

52 See text accompanying notes 50 & 51 supra.
53 20 Ky. L. Rptr. 171, 45 S.W. 515 (Ct. App. 1898).
54 107 Iowa 356, 78 N.W. 63 (1899).
of her husband’s whereabouts, so that the plaintiff could make the arrest and collect the reward. Due to a delay by the defendant which plaintiff claimed was negligent, the plaintiff failed to make the arrest. Plaintiff sued for the reward. The court held that the damages were not too remote and that whether plaintiff would in all probability have succeeded was for the jury to determine. Although the court did not indicate which rule was applied, it appears that an “all-or-nothing” test was used, since plaintiff, under the charge, could have received the entire reward.

Similar disagreement among courts is found in cases dealing with the loss of the chance of winning a contest prize. In *Chaplin v. Hicks*, an English case, plaintiff, one of 50 finalists in a beauty contest, was disqualified as a result of defendant’s failure to notify her of an interview. The court sustained the jury’s award of damages, even though the many contingencies involved made it impossible to assess the value of plaintiff’s loss. Since plaintiff was one of 50 finalists competing for only three awards, the court was probably aware that her chance of winning was something less than 50 percent, yet still had some value. Clearly, this was not an application of the “all-or-nothing” rule. But neither was it an application of the simple mathematical probability rule, which involves reducing the chance to a numerical factor and multiplying that factor by the full value of plaintiff’s future possible gain. The basic definition of probability requires that all events, both favorable and unfavorable, be equally likely to occur before probability theory is applicable. This is not the case here, since decisions by contest judges are highly subjective.

In *Adam’s Express Co. v. Egbert*, an early American case, the court refused to place a value on such a contingent opportunity to win a prize. The plaintiff, who had prepared architectural plans for entrance into a competition, sued a carrier who had failed to deliver his plans for breach of contract. The court denied damages for loss of time and labor, observing that those costs would have been lost in any case had plaintiff’s competition for the prize proved unsuccessful. The court said that plaintiff would have had to show the probability of his winning in order to establish the value of his lost chance. Assigning a numerical value to this probability would have been an onerous task, since the winner would be selected on

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55 [1911] 2 K.B. 786.
56 See note 3(a) supra.
57 36 Pa. 360 (1860).
the basis of many factors, including subjective and personal determinations of quality.\textsuperscript{68}

In \textit{Wachtel v. National Alfalfa Journal Co.},\textsuperscript{69} reminiscent of the \textit{Chaplin} case, the court said that the jury, in awarding damages for breach of contract to a contestant in a magazine contest who had won in her district, could consider such factors as the number of contestants, the number of prizes, plaintiff's position in the competition at the time the defendant cancelled the contest in her area, and the reasonable probability of plaintiff’s winning one of the prizes.

Similarly, although only 20 prizes were awarded among 23,548 contestants, the court in \textit{Mange v. Unicorn Press}\textsuperscript{80} indicated that plaintiff's chance (removed by breach of contract) had some value.

One writer\textsuperscript{81} suggests that through statistical analysis one may estimate the future probability of a subjective, personal judgment — “personalistic” probability, as distinguished from objective or mathematical probabilities. The author further suggests that the application of mathematical probabilities may result in more accurate verdicts, but that the notion that mathematical probability is directly applicable to legal situations is probably invalid. At most it is relevant and helpful. Because the chance is lost, or the future event prevented from taking place, the legal verdict is not susceptible to later verification of the sort that judgments of probability in business or science receive when the event finally occurs.

\section*{IV. SELECTING VARIABLES AND ASSIGNING PROBABILITY ODDS}

Almost every judgment or verdict is dependent in some part on probability. Quite often, however, the probabilities which the law is called upon to consider are not easily expressed as or reduced to

\textsuperscript{68} A case similar to \textit{Egbert}, although not involving a contest, is \textit{Peyton v. Railway Express Agency, Inc.}, 158 F.2d 671 (5th Cir. 1946), in which plaintiff sent a manuscript to a literary critic in hopes that it would get approval, become published, become a bestseller, and be made into a movie. Defendant failed to deliver it, and plaintiff sued unsuccessfully for the value of possible book and movie rights. Plaintiff's success as an author was based on a number of highly contingent factors, the failure of any one of which, no matter how likely the others were to occur, would have spelled complete failure for plaintiff. The court evidently considered all of the factors to be of low probability. To attempt to assign numerical values to the various contingent factors would, again, have been an impossible task.

\textsuperscript{69} 190 Iowa 1293, 176 N.W. 801 (1921).


\textsuperscript{61} Note, \textit{Damages Contingent Upon Chance}, 18 RUTGERS L. REV. 875, 881-82, 892-95 (1964). The author presents a detailed account of the uncertainty in applying mathematical probability to cases involving damages for lost future expectations.
numerical values. There would be no disagreement among mathematicians regarding the probability of drawing two black balls from a box containing three red and four black balls, because there is a closed system in which the probabilities may be determined mathematically, and because all possible events — favorable and unfavorable — are equally likely to occur.

The criminal case considered earlier also presents a closed system, at least as to the variables considered by the court. The closed system is San Pedro, California, and the probabilities of some of the variables considered could be determined mathematically to a fairly high degree of reliability by using census reports, motor vehicle registrations, and other public records and statistics. Beyond this, however, there is a critical difference between the San Pedro case and the red and black ball exercise: one of the most important considerations in the use and reliability of a mathematical probability system rests upon the selection of the factors or variables. Whereas the box of colored balls offers a fixed set of variables, the San Pedro situation introduces the danger of including nebulous and meaningless variables simply for the purpose of “ballooning” the numerical odds to ridiculous proportions. Examples of such variables might be that it was a clear day (when the rainfall in southern California is negligible), that the event occurred at 11:10 a.m., that it was Thursday, and that the woman was wearing slacks. The addition to the formula of each new variable, whether or not it is relevant, increases the mathematical odds against a duplicate occurrence.

The selection of such variables requires a rational basis in fact. The examples of irrelevant factors cited above have no more peculiar relationship to this sequence of events nor to these defendants than to any other events or defendants. These irrelevant factors are not static conditions or striking and telling permanent physical traits, but are subject to change and therefore can neither serve as a basis for subsequent identification nor be subject to later verification. In fact, even the relevant characteristics descriptive of the couple in question and acceptable to the court, except the fact that they were an interracial couple, were such that they could have been dramatically changed prior to trial and simply not been available for the purpose of identifying the defendants. The woman easily could have adopted another hairstyle to replace her ponytail; she need not

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62 See note 3(c) *supra.*
63 See text accompanying note 46 *supra.*
64 See note 9 *supra.*
have remained a blonde; the man could have shaved his beard and painted the yellow Lincoln another color.

Moreover, even if care were taken to select only variables which were clearly relevant, the San Pedro situation would still differ critically from the box-of-balls game, in that the probabilities to be assigned to each variable are themselves subject to question. Let us take as an example the factor of the interracial couple. The only reliable way to assign a numerical value to such a factor is to consult census figures on interracial couples, if such figures are recorded. But this rests upon a rather important assumption — that the two were married. Why could not the bandits have been any white woman and any Negro man who struck up an acquaintance in San Pedro? If this were the case, census figures would be useless for assigning a numerical value to this factor. Since there was no evidence that the suspected couple were married, although the defendants were, the assigned 1-to-1000 odds that the couple sought would be Negro-white may have been far too great.

Implicit in another State's decision in a criminal case is the recognition of the applicability of compound probability theory to the law. Although the court based its decision, at least in part, on that law, it failed to face up to the critical questions affecting the reliability of the formula's use — proper selection of variables and assignment of valid probability values. The Court of Appeals of Maryland said, in a criminal proceeding where the State's case rested upon the identification of the accused by the prosecuting witness as the man who assaulted her, and upon the accumulation of circumstances tending to corroborate her testimony, that: "None of these circumstances, standing alone, would prove conclusively that appellant was the guilty man, but taken together they constitute a chain of circumstantial evidence tending to corroborate the testimony of the prosecuting witness . . ."66

The first three circumstances mentioned in the footnote would fall near the uncertain end of the spectrum. These factors do not lend themselves to subsequent verification. It would be nearly im-

65 Shanks v. State, 185 Md. 437, 45 A.2d 85 (Ct. App. 1945). The circumstances cited by the court were: (1) the defendant boarded the streetcar near the scene of the crime a short time after the assault was committed, (2) he had blood on his coat, (3) the blood on the coat was of a type different from that of Elizabeth Moore with whom he said he had had a fight, (4) the blood was of the same type as that of the victim (prosecuting witness), (5) the prosecuting witness was bleeding, with blood running into her eyes and onto her clothes after the assault, and (6) blood of that type was found in the snow at the scene of the assault.

66 Id. at 442, 45 A.2d at 89.
possible to assign to them numerical values that had any realistic meaning. Such evidence is far more susceptible to the drawing of inferences than to the assigning of mathematical probabilities. No doubt strong inferences may be drawn from such evidence but hardly precise, reliable mathematical conclusions based on probability statistics.

But this is not the limit of the potential danger from including irrelevant factors. Their treatment can be equally baneful. For example, let us again consider the San Pedro case. Assume that the Negro represents the same proportion (6 percent) of the population in San Pedro as in California.\(^67\) If we assume a closed system of 100 persons, six Negro and 94 white, and of the six, three were male, and of the 94, 47 were female, we could determine the pure mathematical probability that any two people would be grouped as Negro male-white female.\(^68\) That probability is \(3/100 \times 47/100 = 1.41/100\). Obviously these odds are considerably less than the assigned odds of 1/1000. Further distortions will arise if we split our sample group into two closed systems — males in one and females in the other. In the first we have 47 white males and three Negro males and in the other, 47 white females and three Negro females. The probability of selecting one white female and one Negro male is \(3/50 \times 47/50 = 1.41/25\).

We may further alter the odds by splitting our sample group on the basis of color — 47 white females and 47 white males in one system and three Negro males and three Negro females in the other system. The probability for the same arrangement as in the first two situations is \(1/2 \times 1/2 = 1/4\). This kind of manipulation is possible because here there were more distinguishing characteristics (sex and color) between the events than there were in the earlier example (color only).\(^69\)

As we have seen in the San Pedro case the selection of the interracial couple was based not only upon an unverified assumption, but it was one that may have been chosen for its emotional appeal and thus may have prejudiced the defendants.

\(^{67}\) U.S. CENSUS OF POPULATION, STATISTICAL ABSTRACT OF THE U.S. 27 (86th ed. 1965). These figures are based on the 1960 census. No statistics are recorded for the Negro-white percentages in the San Pedro population. There are figures on the white-nonwhite percentages in the population, but it was felt that these figures would be no more accurate than those selected for the purpose of analysis since the nonwhite population in San Pedro includes a high percentage of people of Mexican and Indian ancestry.

\(^{68}\) See note 7 supra, example 2.

\(^{69}\) See note 7 supra, example 1.
Similar distortion and inaccuracy lurks in the area of interpretation of such probability expressions, even after proper selection of relevant factors, assignment of valid probabilities, and proper treatment of the factors. For example, assume that the question of fact is whether a given toss of a coin was heads or tails. If it is established that on nine successive tosses of the coin previous to the one in question it came up tails, it could not be argued that, since the odds were $1/2^{10} = 1/1024$, or 1023 to 1, against tossing 10 tails in succession, the probability in favor of a head on the toss in question (the 10th toss) was also 1023 to 1. The crux of the matter involves a perspective in time. The probability of tossing 10 successive tails at a point in time prior to tossing the coin for the first time or prior to the occurrence of any of the 10 independent events, is 1023 to 1 against. The probability of getting heads or tails on any given toss just prior to that single toss is one in two $(1/2)$ regardless of whether it is the first or the 10th toss.

To say that nine successive tails had been tossed is simply to say that what was $511$ to 1 against occurring, before any of the successive independent events occurred, had in fact happened. However, the fact that nine tosses had been made previously would be relevant to and probative of the question whether any one of the nine tosses resulted in tails or what the probability was that out of nine tosses of a coin, one toss would be a tail. This is so because the probability of tossing either a head or a tail increases and approaches a limit of $1/2$ as the number of tosses increases.

The inclusion of irrelevant factors in the algebraic expression of compound probability increases the odds against the occurrence of a similar situation duplicating those factors under consideration. Where such odds are high, the layman tends to accept the conclusion suggested by or flowing from them as conclusive; and, where they are low, he tends to reject the conclusion without consideration of the underlying facts.

Perhaps it could be argued that, when compound probability is applied to a number of individual factors whose individual odds are relatively small but whose collective odds are extremely high, the resulting postulate should not be accepted as conclusive but only be given its proper weight by the trier of fact. Other factors whose individual probability odds are extremely high without the application of compound probability (e.g. actuary tables, blood tests) perhaps should be accepted as conclusive.

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70 See note 3 (a) supra, example 2.
Factors may be interdependent; that is, their probability odds may vary inversely or directly with conditions or with each other. Contrary to the ballooning effect, if the probability of any one factor selected is or approaches zero, their product and the conclusion based thereon, strictly speaking, is negligible and approaches zero; no matter how likely the other dependent events are to occur, the ultimate or combined independent event in issue would be unlikely to occur.

Without going further, we can appreciate the importance not only of the selection of variables and factors but of the treatment of them as well. In the world of the lawyer, there is likely to be little data upon which a mathematical expression of the probabilities involved in determining an issue of fact in litigation can be validly based. Nevertheless, a rational judgment may often be made in which numerical probabilities, while not conclusive, may be considered as enlightening, so long as care is exercised in selecting the system and the variables, and in realizing what is sought to be demonstrated by each factor. The dangers in judicial use of mathematical probability theory lie not in the theory itself, but rather in its high susceptibility to misuse.

V. Guidelines for the Practitioner

As we have seen, when the subject in question involves a closed system and the subject or event is susceptible to subsequent verification, sophisticated devices are available for measuring or counting the frequency of occurrence of that event, and reliable probabilities may be empirically assigned by experts in the event. Absent such circumstances (a closed system), resort should be had to experts in statistical and mathematical probability. It is prob-

71 See notes 51 & 58 supra and accompanying text.
72 The product of any two or more algebraic or arithmetic factors will be zero if any one of the factors is zero. See note 58 supra and accompanying text.
73 See text accompanying notes 63 & 64 supra.
74 The process which describes the reduction of individual probabilities to their numerical equivalents involves three techniques. The first technique is one in which the probability can be determined mathematically within a closed system, that is, a sample space in which every possible result, called sample points, can be described and identified. It is necessary that probabilities be assigned to each of the sample points in the sample space before applying, for example, compound probability. See note 9 supra. Since the interpretation of probability is going to be stated in terms of frequency, the probability that is assigned to a given sample point should be approximately equal to the proportion of times that the sample point will be obtained, or is expected to be obtained, in a large number of repetitions. This frequency interpretation of probability requires that probabilities be positive and that the sum of the probabilities assigned to the sample points be equal to one. A more advanced discussion of this method is beyond the scope
ably not the province of the lawyer to assign probability figures in the first instance to events with which he has little acquaintance.

Perhaps it should be pointed out at this juncture that what has just been said focuses on the essential question raised by the Risley court's rejection of the expert's testimony; that is, whether a mathematician, expert in the theory and application of statistical and mathematical probability, can state his opinion as to the occurrence or frequency of occurrence of a given event, or whether only one expert in the event may do so acceptably. If the answer embraces the latter, this suggests that a mathematician should not be allowed to state what are the mathematical odds in favor of or against the occurrence of a given event unless such occurrence first has been reduced, or can be subsequently verified, to an actuarial certainty. To argue that statistical and mathematical probability theory is inapposite to any situation except that found in a closed system where all factors or elements may be empirically established is too narrow and restrictive a view of this discipline.

For the attorney it would seem that the critical question involves the selection of relevant factors rather than the initial assignment of probability. The latter is properly the job of the mathematician, actuary, or statistician. In selecting such factors the attorney by practice and training is particularly suited for the task.

It may be argued that, since the factors selected are generally in evidence, they should meet the admissibility standard of and be selected on the same basis as any evidence sought to be introduced. First of all, such factors should be found to be relevant. Second, they ought not to be excluded by any of the specific rules of evidence. Finally, although relevant and otherwise admissible, their use should not so prejudice the party against whom they are sought to be used as to outweigh whatever probative value they possess.

Perhaps a standard resembling a "residuum of legal evidence" of this article. For such a discussion, see P. Hoel, supra note 3, §§ 6.1, 8.2, 8.3, 9, 10, 12.

The second technique is one in which estimates of past experience are projected into the future to provide reasonably accurate predictions of the likelihood of occurrence of similar future events, provided the sample space is large enough to neutralize the effect of statistical error. Actuarial tables are an example of this technique. The last technique that includes judgment, consideration of known factors and past experience, disregard of unpredictable events or human factors, and which combines these subjective considerations, is of the type illustrated by the Las Vegas' bookmakers establishing odds on sporting events (aside from the effect that betting may have on such odds) and demonstrated by the experts in the Risley and Howland cases. See text accompanying notes 8-20 supra.

See text accompanying notes 10-14 supra.
rule appears to be too strict, but beyond this the attorney who is aware of the effect of irrelevant factors on the meaning and accuracy of the conclusions based on compound probability law should be guided by his notions of propriety and fair play and desire for objective accuracy.

VI. THE UTILITY OF MATHEMATICAL PROBABILITY

Mathematical probability is particularly useful where predictions and identifications can be made under circumstances that permit a degree of uniformity in and reproducibility of results that to the scientist approaches certainty. It is useful in considering the existence of certain facts whose existence can be subsequently and independently empirically verified. A New Jersey court has recognized the validity of voice identification techniques and the distinguishable characteristics of the human voice, by compelling a criminal defendant to submit to a tape recording for the purpose of comparing his voice with that of an unknown speaker. Perhaps in the near future this same court or another will accept into evidence identification by "voiceprint.

In the case of lie detector devices, however, there is a critical shortcoming. Test results are designed to say something with regard to the subject's state of mind. Aside from the unresolved constitutional questions, the argument against the use of polygraph or other truth-seeking devices is that such methods have not yet been recognized or accepted by the scientific community. Presumably until that occurs, the legal community is not likely to do so. The polygraph, for example, operates on the theory that a person telling a lie undergoes definitely ascertainable physiological reactions whereas the person telling the truth will show only "normal" re-

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76 See section III supra.
78 This method of identification is based upon the scientist's conviction that the frequencies, loudness, and duration of certain basic phonetic elements, and the energy distribution of the human voice, all of which vary with a number of physiological variables, result in an individual's voiceprint pattern being as unique as his fingerprints. Because of the many combinations and permutations of these variables, it is highly improbable that any two voices would be identical. Thus, to the scientist at least, voiceprints can be used to make a positive identification.
79 See generally A. WESTIN, PRIVACY AND FREEDOM 373 (1967). The author argues that lie detector devices should be used only in situations in which the individual freely consents to their use.
actions. What is measured, then, is physiological change in the subject, presumably generated by emotional stress. The obvious difficulty with this is that these physiological changes may be caused by many stimuli other than lying.

It is suggested there is also a reluctance on the part of the courts to substitute expert opinion on the credibility of testimony for the judgment of the trier of fact. 81

It would seem that other parameters or criteria unique to falsifying, or to a state of mind particularly peculiar thereto, must be identified before the scientist accepts such tests as exhibiting the degree of accuracy that fingerprints, blood tests, or others now show.

Mathematical probability is useful in identifying certain individuals and in establishing legal or causal relationships between past events and such individuals by showing the correlation between or similarity of certain physiological, genetic, psychic, or other characteristics of the individual and certain like characteristics known to have existed or to have been related to the event in question.

It is in this area that compound probability is most apposite. This is true because, although in certain situations each separate characteristic or event may be actuarially shown to exist at a certain rate or frequency and thereby provide a certain degree of reliability, it is the existence or occurrence of a combination of such characteristics or events that tends to establish conclusively the identity or relationship in question. Although certain events occur frequently and certain features appear often, it is the unlikelihood based on compound probability that the same combination of features would appear in another person or that the same combination of events would occur more than once that tends to establish the fact.

It would follow then that in those areas where the facts in question do not occur because some condition precedent does not, and where as a result there is no subsequent verification of the fact, or where no data is available as to the frequency of occurrence of certain events, then mathematical probability is not a very reliable or useful tool. It is not particularly useful as an aid for predicting future events where there is no history of similar past events or where the occurrence or nonoccurrence of the event is dependent upon other factors or personal, subjective judgments not susceptible of present identification.

Mathematical probability is thus most useful in establishing the existence of or identifying facts relating to past events and least use-

81 See A. Westin, supra note 79.
ful in the predicting of future events and in those legal situations (e.g., computation of damages in breach of contract actions) where the chance is lost or the future event prevented from taking place.

VII. Conclusion

The great difficulty in applying the rules of compound probability to the data of evidence lies in the fact that it is a mathematical concept and, as such, appears to lawyers and jurors to be esoteric, in spite of its simplicity. While laymen may accept the assignment of numerical values to the probability of separate events, they may yet resist accepting the conclusion (i.e., the probability resulting from the product) which follows logically from fundamental laws of probability, particularly where the odds are relatively low.

Just the opposite may be argued where the odds are, for example, 12 million to 1 as in the San Pedro case, or 4 billion to 1 as in the Risley case. There the criticism is that such evidence would urge a conclusive effect upon juries, without the usual weighing of probability in which the trier of fact engages. The sheer weight of overwhelming mathematical odds might suggest to the jury a decision in conformity with those odds as the only possible verdict.

It is submitted, however, that these lurking dangers of misevaluation should not serve as a basis for total rejection of probability theory as a factfinding tool. As with any other variety of scientific evidence, the proper approach would seem to be to concentrate, first, upon assuring that a proper basis is laid for the invocation of the mathematical process, and, second, upon the proper instruction to jurors as to the effect to be given the result.

Provided the numerical probability assigned to the occurrence of a given event is based upon valid considerations, and the factors, variables, or events are selected with justification, the application of the laws of statistical and mathematical probability introduces into the law a concept no different from that of giving weight to any circumstantial evidence by the trier of fact. The rules of probability simply give a more definitive picture of the relative value of this type of evidence.