A psychologist concludes that more light would be shed by understanding human behavior factors than from complicated statistical analyses of the uncontrolled world surrounding accidents in everyday circumstances.

The Illusive Phenomena in Accident Proneness

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How shall we determine the presence or extent of accident proneness?

Granted the factor of accident proneness, how shall we come to know its character?

This, in a sense, will be a consumer's report—a report of occasionally desperate attempts to apply the cool logic of statistics to the fetid jungles of accident data. It is the result of some 5 years of delving into innumerable accident records (*1–3*). This faint blaze on my back tracks may help others avoid some of the morasses in which I have floundered on a number of occasions.

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The Extent of Accident Proneness

In view of the wide use and frequent abuse of the term "accident proneness," it would appear to be a required first step that I outline my concept of its meaning.

I conceive of an accident as a condition of liability, as an event subject to and contingent upon the existence of identifiable, at least in a theoretical sense, events.

This position would contend that a constellation of circumstances at the time of an accident determines the occurrence of that accident. Further, the presence of certain events increases or decreases the probability of any given accident. The summation of the probabilities represents accident liability at any given time. Finally, the position maintains that a knowledge of all of the pertinent events prior to the accident permits the prediction that the accident will occur. It, of course, follows as a corollary that increasing knowledge about the factors surrounding an accident will permit its prediction, or, if such factors are manipulatable, will permit the reduction of accidents.

Here is an expository categorization of events which may be called the dimensions of accident liability.

Factors within individual:

Stable individual characteristics (accident proneness). *Examples:* psychomotor capacities, intellective capacities, sensory capacities.

Transitory individual characteristics. *Examples:* fatigue, illness, hangovers, emotional states.

Changeable individual characteristics. *Examples:* low level of training, faulty training.

Factors outside individual:

Stimulus presentation. *Examples:* clarity of cues for response, speed of cue presentation, sequence of cue presentation.

Response demands. *Examples:* speed of response, direction of response, accuracy of response.

Equipment adequacy. *Examples:* materiel failure, calibration errors, response lag.

Activities of others. *Examples:* faulty maintenance, faulty instruction.

Consider accident proneness as a component part of this accident liability. Accident proneness, in these conditions of accident liability, is that category concerned with the stable characteristics within the individual. The other categories obviously could not be considered as proneness on the part of the individual since they either are not stable or not directly under the control of the individual.

Accident proneness, then, may be defined as the continuing or consistent tendency of a person to have accidents as a result of his stable response tendencies. For example, two individuals may fly in the same aircraft and in identical circumstances. Thus, they would have the same situational probability of having an accident. However, one may be inherently a poor pilot in regard to coordinative capacities. He will have, because of this lack of proficiency, a greater probability of having an accident in circumstances requiring coordination. He would then be called an accident-prone pilot.

How may we detect the presence of accident proneness in a population of accidents? Let us recognize certain conditions inherent in our definition of accident proneness. First, it has been described as a continuing factor, and, second, it has been described as increasing the liability of accident occurrence. It follows, then, that, if a group of individuals with varying amounts of accident proneness were exposed to conditions which permitted the operation of these factors of proneness, the accidents of those individuals with high accident proneness would exceed beyond chance expectancy the accidents of those with low accident proneness, other things being equal. The problem is simply one of establishing the fact that certain individuals had accidents which exceeded those expected on the basis of chance, other things being equal.

The Poisson Method

Perhaps the most classical method is the Poisson method (*4*, *5*). The method reveals the statistical problem as a relatively simple one. Given a relatively infrequent event, how will these events be distributed by chance alone? If such a distribution can be derived, a comparison may be made with an obtained distribution of accidents. If the distributions differ, an inference about the operation of non-chance factors may be introduced.

Thus, if 100 accidents are going to be distributed by chance among 10,000 people over a period of 1 year, what are the chances of these accidents occurring to 100 different people as contrasted with some individuals having 2 accidents, some only 1, and some none; or, some individuals having as many as 3 or 4 accidents, some having 2, some having 1, and some having none? Given a chance distribution, how does it compare with the actual distribution of accidents under consideration?

Mathematically, the Poisson distribution, which is merely the binomial distribution with low probability of occurrence, can be used to describe the chance distribution of infrequent events. If the distribution of accident events deviates from that expected on the basis of the prediction of the Poisson distribution, we may state that a beyond-chance factor is operating. This technique has been so sharpened that we may actually estimate the amount of predictable variance which exists above and beyond chance and may further estimate a correlation which could be obtained between perfect predictors and this variance in excess of chance.

The accompanying table presents a mathematically derived chance distribution and an obtained distribution of 7,288 accidents occurring to 17,952 Air Force pilots during an 8-year period (*2*). Let us consider this table.

According to the Poisson method

Number of accidents	Chance distribution: Number of pilots	Chance distribution: Number of accidents of pilots	Obtained distribution: Number of pilots	Obtained distribution: Number of accidents of pilots
0	11, 962	0	12, 475	0
1	4, 856	4, 856	4, 117	4, 117
2	986	1, 972	1, 016	2, 032
3	133	399	269	807
4	14	56	53	212
5	1	5	14	70
6	0	0	6	36
7	0	0	2	14

First, in regard to the chance distribution, if merely the repetition of an accident is to be taken as the definition of accident proneness, some 33 percent of the accidents could be so classified in a completely chance distribution. This is patently absurd.

Second, a casual comparison reveals that the obtained distribution contains individuals who did have accidents in excess of the distribution to be expected by chance. Only 1 pilot would have been expected to have had 5 accidents during this period on the basis of a chance distribution. In actuality, 14 had as many as 5 accidents. None would have been expected to have had 6 accidents if these accidents had been distributed on the basis of chance. In the obtained distribution some 6 individuals had as many as 6 accidents.

A comparison by the chi-square technique indicates the two distributions are significantly different. We must, however, reserve judgment as to the possibilities of inferring that this excess of chance occurrence can be attributed to accident proneness.

The Split-Period Method

Perhaps the most straightforward test of the consistency of accident tendencies over a period of time is the "split-period method." This is based on the determination of the relationship between a number of accidents had by individuals in 2 periods of time. The simplest method is to divide the total period of accident exposure into 2 halves and then determine if there is a relationship between the accidents had by individuals in the 2 periods. The statistical tool would be the correlation coefficient. In actual procedure, the time period is more typically divided into accidents occurring in odd and even periods in contrast to a first-half, last-half division so as to obtain better control of the external characteristics of the time periods.

A distribution of accidents on odd and even days, according to the split-period method, was obtained for the same Air Force population referred to previously. The obtained correlation is 0.107 and is correctable by a Spearman-Brown formula to 0.193 (*2*).

Since a correlation expresses the degree of relationship between two sets of measures, these figures indicate the degree to which the accidents had by a man during one period were related to the accidents he had in a second period. A correlation of 1.00 would indicate that the accidents during one period perfectly predicted the accidents in another period, or, one could infer there was a direct relationship between a man's accident behavior during the two periods of time. A 0.00 correlation would indicate that his accident behavior in the two periods was completely unrelated. The correlations obtained were small but significant, and it would be concluded that some beyond-chance factors were operative in the Air Force population.

It should be noted in passing that there has been, on occasion, differential touting of the Poisson method and the split-period method (*6–8*). It seems appropriate to point out that Jones and I (*9*) have shown that the two methods, derived from essentially independent assumptions, yield operationally identical estimates. We also found that mathematically the identity of the methods can be demonstrated. Practically, it would appear that the choice of the method becomes dependent only on convenience, ease of conceptualization, or personal preference.

External Correlation Method

A further statistical procedure establishing the presence of accident proneness may be labeled the "method of external correlation." This procedure would be dependent on the selection of a measure presumably related to accident proneness. The population would then be measured on this factor, and then these measures would be correlated against the accident occurrence. If this correlation was significant, it would indicate that accidents could be predicted on assumption of accident proneness, and, therefore, accident proneness could be inferred as existent. For example, suppose a measure of intelligence can be shown to be related to accident frequency. Since intelligence is a stable characteristic of the individual, it follows that accidents are to some extent a function of individual accident proneness as partially measured by intelligence.

Limitations of Methods

All of these procedures have their difficulties, however. The prime difficulty lies in the fact that the beyond-chance factors which may be demonstrated by these methods may not be attributed to the existence of a continuing factor of accident proneness alone. A considerable portion of the liability conditions outlined previously may exist commonly with the individual but not be attributed to his own within-person proclivities for accidents.

For example, 2 individuals with precisely the same capacities or proneness potential may be assigned throughout the accident period to 2 different situations which require different complexities of response. The individual who is consistently required to respond more effectively is likely to make more errors, and accidents would be more frequent throughout the situation, and yet he could hardly be considered more accident prone—consistently more accident liable, yes, but not more accident prone. In fact, quite frequently the converse is true since better men are frequently assigned to more difficult situations. Or, again, frequency of exposure may be different for different individuals during the accident period. A man exposed twice as frequently as another man is likely to have more accidents, but again this could not be called accident proneness.

All instance variations in liability throughout the period under study will result in beyond-chance distributions, if they are systematically associated with certain individuals and not with others. It follows that the extent to which all factors, other than the accident-prone factors which are included in the listing of the dimensions of liability, are equalized among the population under consideration defines the extent to which the deviation from chance established by the methods described can be attributed to accident proneness.

As a point of fact, with each increasing restriction on the Air Force population previously used, there was a reduction in the significance of deviation from chance. Until, for example, training accidents (which impose maximum restriction in regard to age, training, exposure, and type of aircraft) revealed no deviation in their accident repetition from that which would be expected by chance. The same holds true for selected groups of jet accidents in which exposure was largely equalized (*2*).

The Clinical Method

One further method may be mentioned as a tool for probing the existence of accident proneness. It is not statistical, but may be described as the "clinical method," a method which involves very simply a post hoc detailed analysis of the characteristics of individual accidents and individual accident histories. If, for example, a man consistently has the same type of accident under varying circumstances, and these accidents may be attributed to some characteristic inherent in that man, at least these accidents and perhaps others are attributable to accident proneness.

The clinical method has its advantages and disadvantages, which have been, and are being, argued independent of the present problem. It yields no satisfactory estimate of the extent of accident proneness. I am somewhat frightened by the "seek and ye shall find" phenomena. In the typical complexity of the accident situation I can almost always find that which I am looking for if I know what I am looking for in the first place.

Perhaps the main advantage inherent in this procedure is the liveliness and convincing quality of the results and its usefulness in developing hypotheses to be further investigated.

The Nature of Accident Proneness

Let us assume that either on the basis of faith or fact we are convinced a significant proportion of accidents is determined by accident proneness in a particular population. What do we do next? The mere pointing to the fact of accident proneness is hardly more useful than pointing to sin. We must somehow know its characteristics to be able to deal with it.

Our basic paradigm is not difficult to conceive. We need measures which are presumably related to this intervening concept of accident proneness. We need measures of the accident event. Finally, we need to determine whether our measures of accident proneness are related to or predictive of accidents.

Certain difficulties typically follow from the nature of accidents and accident records. The definition of the accident is a difficult one, yet this is a first requirement in a reasonable test of the predictability of our concepts concerning accident proneness. It is a bit absurd to suggest that, for example, an intelligence test could predict an accident resulting from the breakdown of equipment, when this breakdown was independent of the operations of the individual. In other words, we should limit ourselves to accidents for which the operator could at least theoretically be held responsible.

Unfortunately, even a simple dichotomy of accidents into personal responsibility and nonresponsibility is frequently unreliable. When we further try to dimensionalize accidents within a personal responsibility category, vast confusion tends to reign. Not long ago, on reviewing psychological coding systems for accidents, DuBois and I found that the commonality of classification of the nature of the accident usually ranged from about 33 percent agreement between 2 raters to a maximum of about 70 percent agreement between the 2 raters (*3*). The variations seem to be primarily related more to the number of possible categories to which the accident could be assigned than to any descriptive nature of the codings used. So long as the definition of an accident is not at all clear—and to date I know of no satisfactory, psychologically meaningful dimensionalization of this event—our designs will be weak.

On the other end, there are many problems inherent in obtaining measures which we are to relate to this chaos. Most of the problems at this end stem from the fact that accidents are infrequent phenomena. This means that, if measures are to be collected prior to the occurrence of an accident, the data collection must be an extensive one. Frequently, as many as 10,000 measures must be obtained on a population in order to yield measures on 10 individuals who are going to have accidents. An alternative procedure is the measurement of a limited number of individuals and then waiting for the passage of an extensive period of time until the low probability of accidents yields sufficient cases. This procedure is further complicated on finding that the measures taken may be quite meaningless by the time the accident occurs. Then, there is the post hoc method, the method of obtaining data after the accident has occurred. This method contains all of the faults of a posteriori reasoning noted in the clinical method.

Although there are ways around these problems, one becomes discouraged. Faith, frustration, tolerance, or funds are necessary to sustain us through the travails involved. There is also, of course, the question of what measures should be used, which involves an appraisal of the state of psychology itself. I will merely understate the case by saying that much more needs to be known about the nature of man.

The most adequate studies of the role of psychological factors in the development of errorful behavior, in short, a study of accident proneness, will best be performed in the laboratory situation even though there are inherent difficulties in translating laboratory findings to the operating situation. However, I personally feel that these difficulties will be far less the difficulties inherent in the rough and ready analysis required of the present complexities of the uncontrolled world surrounding operational accidents.

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Nursing Home Project Approved

The first project to be constructed under the provisions of the Medical Facilities Survey and Construction Act of 1954 (P. L. 482, 84th Cong.) has been approved.

It is a 53-bed nursing home addition to the Pinal County General Hospital at Florence, Ariz., which will be used for nursing and medical care of the aged, and will be operated by the hospital.

At present, there are no nursing home facilities in the county, and patients who could be cared for in a nursing home are occupying more than 12 percent of the 86 beds in the general hospital. The nursing home will use the hospital's special services and personnel and will, when necessary, transfer patients to the hospital for medical or surgical treatment.

Estimated construction cost of the nursing home is $240,000, toward which the Federal Government will contribute half and Pinal County the other half.