7 RESEARCH ON ACCIDENT PRONENESS

THE READINGS:

THE IDEA THAT SOME PERSONS or groups appear to be especially vulnerable—or invulnerable—to misfortune is very old. It is a fundamental theme in history, art, and literature. It serves as the basis of much of ancient myth and modern fiction and is widely represented in the primitive world of totem and taboo. The story of Achilles shows well both its antiquity and importance, but it is seen in its fullest early development in the Book of Job, in which the interrogations and pronouncements of Job's pious friends illustrate the common inclination to attribute individual misfortune to undesirable personal characteristics that can be expiated, or at least uncovered, by appropriate therapy.

Against this background it is not surprising that the idea of accident proneness as a *scientific* concept concerned with unequal personal liability to accidents was greeted by research worker and layman alike with enthusiasm. In the 1920's, when it was introduced, attempts to explain the everyday world in scientific terms were increasingly numerous, and it is probable that this climate favored its popularity.*

Accident proneness proved to be one of those concepts which revolutionized a field of scientific investigation. And, as so often happens with such classical formulations, the disciples who followed pushed the concept far beyond what its originators intended. Coming at a time when the engineering approaches to accident prevention appeared to be reaching a point of diminishing returns, this brave, supposedly new idea of human vulnerability appeared to offer fresh hope for the conquest of accidents. Fifty years after its initial formulation in Great Britain by Greenwood and Woods, it still exerts a major influence upon accident research. For this reason, we feel it worth while to devote a separate chapter to this behavioral approach.

What is meant by accident proneness? First we have to distinguish between accident repetitiveness and accident proneness. The former simply refers to the descriptive fact that some individuals have more accidents than others, a distribution statistic that is true for a great many other social, psychological, and medical phenomena. There can be no quarreling with this statistical truth, but this is not what is meant by accident proneness, although a large number of studies proceed as if this were the case. Rather, accident proneness is offered as the *explanation* of why this distribution occurs, and it is this point that has aroused first minor, and now major, protest. As a theoretical explanation of repeated accidents on the part of the individual, accident proneness is a *psychological* abstraction and, as such, it is assumed to refer to the existence of an enduring or stable personality characteristic that predisposes an individual toward having accidents.

The critical words in this definition are the adjectives *enduring* and *stable*. Various researchers have attemped to identify such stable personality characteristics and have listed many unvalidated, negative personality traits, foremost among which are aggressiveness, impulsiveness, maladjustment, antagonism toward authority, immaturity, in-

* The notion that increased accident liability could be studied scientifically soon appeared in literature. For example, the plot of Thornton Wilder's Pulitzer Prize novel, *The Bridge of San Luis Rey* (1927), concerned an attempt to find the pertinent characteristics of a group of persons killed in the collapse of a bridge. "If there were any plan in the universe at all, if there were any pattern in a human life, surely it could be discovered, mysteriously latent, in those lives so suddenly cut off. Either we live by accident and die by accident, or we live by plan and die by plan. . . . But these occasions of human woe had never been quite fit for scientific examination. They had lacked what our good savants were later to call *proper control*." [Wilder's italics.]

considerateness, and hostility. Dunbar, one of the prominent exponents of the accident proneness concept, so described the accident-prone individual,[1,2] as did Tillmann and Hobbs in a study discussed later in this chapter.

It should be obvious to the reader that so indiscriminate a listing of personality traits could hardly be expected to define a *single* type of individual. The list of distinguishing characteristics changes from study to study; the results concerning any single characteristic are inconsistent; and, in general, the correlations between personality characteristics and, hence, their predictive value, are extremely low.[3-5] The bulk of evidence indicates that there is no such thing as a single type of "safe" or "unsafe" individual. Rather, each individual has a *range of behavior*, any portion of which may be safe or unsafe, depending on the environmental hazards to which he is exposed. Thus, instead of a single type of accident-prone individual, there may be many reasons why some individuals may incur more accidents than others.

For example, individuals may vary considerably: (1) in their exposure to hazards; (2) in their sensory, neural, and motor functioning; (3) in their capacity for correctly recognizing and making judgments concerning hazards; (4) in their experience and training; and (5) in the extent to which they are exposed to pertinent social and other environmental stresses. In addition, individual variations in susceptibility to trauma (see Chap. 9) may bias the data when accidents are defined in terms of the occurrence of given degrees of structural damage or personal injury. Finally, because individual variations in accident rates may result completely from chance, it is never adequate to show merely that a small fraction of similarly exposed individuals accounts for a disproportionate share of accidents. Rather, it is necessary to demonstrate that the disproportion observed is greater than that which would be commonly expected on the basis of chance alone. This has been overlooked by many, if not most, of those who have concerned themselves with accident proneness.

From this list it should be clear that accident proneness—as a psychological concept—must be viewed as only one possible explanation for individual variations in accident rates. This is not to deny the occasional usefulness of the concept but to indicate that there are other explanations which must always be considered.

ACCIDENT PRONENESS

— Edward A. Suchman, Ph.D., Alfred L. Scherzer, Ph.D.

The concept of accident proneness has been criticized on statistical, methodological, and theoretical grounds. Some of these criticisms are summarized in the following report.

* * *

ONE IDEA prevalent in accident research is that a high frequency of accidents incurred by certain individuals may be explained in terms of some abnormal personality characteristic of those involved. There is a great deal of confusion and unprofitable debate about this concept of accident proneness. It is our contention that accident proneness does deserve a limited place in accident re-

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search but not the central position it is now given by many research workers.

The concept of accident proneness arose out of the observation that certain adults and children seemed to have more accidents than others. The term implies the existence of a particular personality type which is predisposed toward having repeated accidents. This predisposition is regarded as a psychological abnormality due to some underlying neurotic or psychopathic condition. For example, as summarized in the *Proceedings of the First Conference on Home Accident Prevention*, "The accidents, then, might well be unmotivated, and the defect a developmental one in the ego-control mechanisms."

Certainly a psychiatric point of view justifies the hypothesizing of a neurotic tendency on the part of some adults and children to inflict self-injury through deliberate accidents. Such clinical cases have been reported by various psychiatrists. However, can one use such clinical evidence to justify the use of accident proneness to explain all, or even most, of the cases of individuals who have a high frequency of accidents?

There are several reasons why this extension of a legitimate psychiatric concept is unwarranted. These reasons are statistical, methodological, and theoretical.

The existing evidence has serious statistical shortcomings. Since chance plays a part in many accidents, we would expect to find that during any given period a certain proportion of the population would suffer an inordinately high number of accidents *by chance alone*. The concept of accident proneness is based on the assumption that the membership of this group, in terms of individuals, remains unchanged with the passage of time. Actually, as Schulzinger observes, "The evidence indicates that if the period is sufficiently long, the small group of persons who are responsible for most of the accidents is essentially a shifting group of individuals with new persons constantly falling in and out of the group." Moreover, statistical correlations between present and future accidents are often low; the mathematical models and techniques utilized to establish these relationships are subject to severe criticism by responsible theoreticians; observable injury or damage are not necessarily adequate indicators of the occurrence of accidents; and the multitude of possible intervening factors requires statistical controls which are not generally applied. After considering accident proneness from a theoretical and mathematical point of view, McFarland concludes that the scanty evidence which remains after critical review may hardly be taken as adequately supporting the concept.

From a statistical point of view the problem of prediction becomes extremely important as proof or disproof of the concept of accident proneness. To what extent can we predict that individuals with a high frequency of accidents in the past will continue to have more than their share of accidents in the future? Very few studies have attempted to do this.

* * *

Methodologically, too, there are a number of inadequacies in the current research on accident proneness. Perhaps most important is the failure to control an environmental exposure or risk. Certain individuals are more likely to be exposed to hazardous occupations or environments and thus to incur more accidents. Comparisons, therefore, must attempt to equate individuals on exposure before comparing them on accident frequency. Unless we take this differential exposure into account, we are likely to attribute to personality characteristics what is in fact attributable to the environments that attract such personalities.

There also appears to be some confusion between the concept of predisposing factors and accident proneness. Because certain groups of individuals (*i.e.*, young males) are apt to have more accidents than others, we cannot say that individuals who belong to these groups are accident-prone. There are a great many social factors which contribute to a differential rate of accidents among

subgroups of the population, and these factors have to be taken into account in explaining why some groups have more accidents than others.

Finally, from a theoretical point of view, there is some reason to doubt the existence of any identifiable personality type that could be labeled as the accident-prone personality. Dietrich is not fully convinced of the accident proneness concept because the accident repeater has not been successfully identified as a psychological entity. In fact, most studies have shown highly contradictory results concerning the traits of "the accident-prone personality." For example, in some cases this may be an overly timid individual, whereas in others this type of individual is more likely to be aggressive. Unless the accident-prone individual can be identified and described as a meaningful type, it would seem to be more useful to identify those separate personality characteristics that are more or less associated with repeated accidents.

This analysis presents only some of the reasons why the concept of accident proneness must be viewed with caution. Certainly the evidence in its support is not conclusive. It seems likely that greater progress will be made in accident research through concentration upon the specific causes of repeated accidents and through restricting the concept of accident proneness to the limited number of psychiatric cases in the total population of accident repeaters.

The foregoing discussion should suffice to indicate that we are dealing here with a greatly misunderstood concept. In view of this, and in view of its considerable influence on accident research, we are reproducing below three of the early reports dealing with the subject. We do this not only for historic purposes but also because the first two remained the best work by far that had been done on the problem until the recent work of Cresswell and Froggatt (see below). We include also two more recent studies, one of which stresses a statistical and the other a clinical approach.

THE INCIDENCE OF INDUSTRIAL ACCIDENTS UPON INDIVIDUALS WITH SPECIAL REFERENCE TO MULTIPLE ACCIDENTS

—Major Greenwood, Hilda M. Woods

We begin with the classic paper in the field. As so often happens with new concepts, its originators state their case with greater moderation than their disciples. Greenwood and Woods did not describe some workers as "prone" to accidents† but developed the thesis that a small minority of individuals have greater numbers of accidents than would be expected on the basis of chance alone. This theoretical formulation led others to undertake hundreds of such studies and hence served as the basis for much of the research on accident proneness.

By studying accidents among workers in a British munitions factory during World War I, Greenwood and Woods found that accidents were not evenly distributed but that a relatively small proportion of the workers had most of the accidents. To explain this phenomenon, they proffered the theory of unequal initial liability—*i.e.*, that some individuals are inherently more likely to have accidents than others. Taking the accident records of a large number of work groups, they compared the observed frequen-

† See the preface to Newbold's work, other portions of which are reproduced in this chapter.

cies with three alternative hypothetical distributions. Further checks on consecutive time periods led them to propose that the presence of individuals with unequal liabilities best explained all the facts.

WHEN A NUMBER OF PERSONS engaged upon a specific task are observed over a period of some weeks or months, they are often found to have sustained a certain number of casualties; if such casualties are so trivial as to permit the victim to continue work, it may also be observed that the same person is injured more than once, so that the statistics of the whole period provide a certain number of persons who have passed through unscathed, some who have been injured once, others who have been injured twice, and so on.

A frequency distribution of this kind arises under various conditions and the proportions of the whole population found in its different subdivisions will be regulated by the group of causes which determine the happening of the event in question. If for instance we distributed amongst a set of families, each containing the same number of members, some source of infection (perhaps a person suffering from influenza might go to reside in each family), then we should ultimately have statistics of multiple cases of influenza, some families having no cases (other than that of the intruder), some having one, two, and so forth. But even without the supposed importation, and if sickening with influenza were as much a matter of chance as the drawing of an ace of spades from a well-shuffled pack of cards which we should do once on the average in every 25 trials, we should still expect to find that the statistics give instances of families with more than one case of influenza.

To take another illustration, let us suppose that 100 equally capacious and equally accessible pigeon holes are bombarded with 20 balls, none of which can fall clear of the pigeon holes altogether, then the chance of any one ball lodging in any particular pigeon hole is one in a hundred, and at the end of the bombardment the distribution of pigeon holes with 0, 1, 2, etc. balls in each is given by the 21 successive terms of:

$$100\left(\frac{99}{100}+\frac{1}{100}\right)^{20}$$

But the pigeon holes might not be of equal size. If some were very much larger than others, the former would receive a greater share of the balls and the distribution would be very different from that just given. Similarly if the pigeon holes changed size after the bombardment had commenced, the distribution would be affected. The extreme limits of the two modifications would be reached if either (*a*) all the pigeon holes save one were covered in, when the final distribution would necessarily be 1 pigeon hole with 20 balls and 99 with none, or (*b*) if directly a ball entered a pigeon hole a lid fell—as in the trap nest of a poultry fancier—which would lead to an ultimate distribution of 80 pigeon holes with no balls and 20 with one each.

These examples, although their analogy to the subject we are engaged upon is but imperfect, start a train of thought. Knowing the form of the ultimate distribution of pigeon holes with various numbers of balls, it is evidently practicable to form a judgment as to the nature of the causes which have operated in the distribution, since these will completely determine the result. We say advisedly "*form a judgment as to*" and not "*prove what was*" because an inverse problem of this kind presents certain difficulties which we have no space to discuss. Following up this trail might it not similarly be

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possible, from a consideration of statistics of multiple accidents, to reach a judgment as to factors producing these?

To make our point clear, let us discuss the genesis of accidents more at large. We have not, however, to consider any general influences common to the whole number of persons studied. Such influences will not affect the distribution of accidents as between individuals, but will modify the general scale; they are of course of immense importance because they may determine the total numbers of accidents sustained, but need another method of investigation and have in fact been studied by other workers. We are only dealing with the differentiation of individuals.

The simplest hypothesis is that there is *no* differentiation, that industrial accidents are really accidents in the strictest sense, just as it is an accident if one draws the ace of spades from the well-shuffled pack, an accident if a particular pigeon hole receives a ball at any particular throw and so on. In that event, the statistics of multiple accidents would conform to the type of a pure chance distribution of which the first arrangement of pigeon holes imagined above is one illustration.

The most obvious modification of the pure chance scheme is to suppose that the workers did all start equal, but that an accident having happened to any individual that individual's chance of sustaining a second accident became different from what it was before. Such a train of events is common enough in human life. A person may acquire some disease by the merest accident, but passing through the attack will profoundly modify his chance of acquiring it again when the original conditions are, in all other respects, reproduced; he may be practically immune or conversely he may be much more sensitive to infection. The analogous schema in our sets of pigeon holes is that of the trap nests, although the analogy is imperfect because in that case not only is the future chance of the particular pigeon hole modified, which is correct, but, by the conditions that all 20 balls must ultimately rest somewhere in the 100 pigeon holes (introduced for simplicity) the chance of the empty pigeon holes is also modified, which is wrong, for the happening of an accident to one person should not generally affect anyone else's chance.

Thirdly we might suppose that all the workers did not start equal, but that some were more liable to suffer casualties than others; suppose there were only two classes, clumsy and careful people, then the analogy would be 100 pigeon holes, 50 having an opening of 1 square foot and 50 having an opening of 2 square feet and we should get another special distribution of multiple accidents.

These three hypotheses correspond to three distinct policies of organisation.

If industrial accidents were found to be allocated upon a pure chance schema, the diminution of their number would be effected by a change of scale through administrative reforms inspired by researches into general conditions, but not into the individual physiology or psychology of the worker. Were the second mentioned hypothesis in better accord with the facts, there would be need for consideration whether the enhanced liability to accident after a first casualty (supposing the bias were in that direction) might not be reduced, perhaps by a compulsory period of rest, possibly by a short interval of different work. If, on the other hand, the third possibility materialised, it would follow that both initial selection of recruits and also a rapid elimination of those sustaining multiple accidents should have a great effect in reducing the casualty rate of the factory.

It seemed therefore possible that an investigation of the statistics of multiple accidents might yield results of some practical importance and we felt justified in making a preliminary survey of the field; a full discussion of the various mathematical questions suggested by the data will be published in a memoir by Mr. G. Udny Yule and one of us at a later date.

Statistical Methods

When it has been desired to ascertain whether the distribution of multiple events actually observed in any case were such as might arise upon the hypothesis of a pure chance determination, the schema of pigeon holes into which balls are tossed has been adopted by the best modern exponents of applied mathematical probability.

This schema was used by, for instance, Professor Karl Pearson in a study of the occurrence of multiple cases of cancer in houses and in connection with the similar problem of recurrent enteric fever in houses. When the number of pigeon holes is very large but the ratio of balls to pigeon holes finite, the formula admits of rapid computation by means of an approximation.

The *a priori* objections to this schema as a proper representation of what occurs in a chance distribution of accidents are formidable. In effect, the assumption is made that n accidents *must* happen to the N persons, all that we have to do being to distribute them; but it might properly be retorted that a true analogy is that of a platoon of soldiers exposed to fire of whom a certain number are struck once, some twice and so on. Now suppose the number of bullets discharged (irrespective of whether they find billets or not) is M and the number of wounds inflicted (again irrespective of whether they are inflicted upon different bodies) n; then the chance of being struck being p and of being missed $1 - p = q$, we can determine values of the unknown chance from the mean and second moment of the distribution; we take the chance of being wounded as not given *a priori*.

In practice, however, these two fundamentally different methods do not really lead to widely divergent final distributions. This is illustrated by the following examples. In A, 400 accidents are distributed amongst 10,000 persons by the pigeon hole schema. In B it is assumed that the same number of persons were exposed to risk of accident during 4 units of time, the chance of having an accident in each unit being one in a hundred and the unit so small that no two successive accidents could occur within it.

We have:—

Accidents per person	*Frequency by A*	*Frequency by B*
0	9608	9606
1	384	388
2	8	6
3	0	0

The reason of this accord is that in each case the form of distribution approximates to that obtained by the series mentioned in the first section of the appendix, viz.:—

$$e^{-\lambda} \left(1 + \lambda + \frac{\lambda^2}{2!} + \frac{\lambda^3}{3!} \cdots\right)$$

where λ is the number of accidents divided by the number of persons. Consequently whenever the conditions are such that the chance of sustaining an accident must be deemed small (and these conditions are fulfilled in the majority of cases), the unmodified pigeon hole schema is probably a quite adequate test of the likelihood that the distribution is one of pure chance in origin, and this is the test we have uniformly applied.

The second hypothesis to be tested, viz., that in a population initially all equally liable and exposed to risk, those who experience first accidents are by virtue of that experience rendered more or less liable to have another accident, is *not* satisfactorily imitated by the modification of the pigeon hole schema which we indicate in theAppendix [omitted].

There is no algebraical difficulty in devising a much more appropriate schema, one not suffering from the obvious defect that increasing the size of certain pigeon holes diminishes the size of the remainder, the total space within all the pigeon holes together being kept constant. The requisite algebraical formula has been worked out and will be given in the paper by Yule and one of us to which reference has been made. But it was found on trial that this more correct formula produced a distribution very similar to that reached with the modification of the pigeon hole schema just mentioned, while actual fitting to data was extremely

laborious and not in general practicable in terms of the lower moment coefficients. Hence, although fully alive to the imperfections of the modified pigeon hole formula, we have utilised it as some test of the physiological theory.

The third hypothesis, viz., that of *ab initio* differentiation, is we think quite sufficiently tested with the aid of the third formula in the Appendix. We do not of course mean that the assumption involved in equation (5) of that Appendix is necessarily correct, but merely that it provides the kind of distribution which we should naturally anticipate and has the advantage of leading to a series the constants of which can be deduced from the first two moments of the statistics.

These three methods then, that of a Simple Chance Distribution (denominated in our tables by the letters C.D.), that of a Biased Distribution (entered as B.D.), and that of a Distribution of Unequal Liabilities (indicated by U.D.), have been used throughout. A criterion of agreement between the deductions from the formulae and the statistical facts has been obtained by using Professor Pearson's Goodness of Fit Test as modified by him in the under-cited paper.

We shall first set out the tabular results yielded by data recording the numbers exposed to risk (we of course satisfied ourselves that the material conditions of exposure to risk were really approximately constant in each set of data), and the distribution of multiple accidents. We shall then examine some statistics providing more detailed information (Tables I.-IX.).

As will be seen from the headings of the tables, the sources of the data are various; sometimes we had merely a record of the total numbers employed in a particular shop over a given period, on other occasions we were furnished with the records of a number of women chosen at random, *e.g.*, by the fact of their names occurring on particular pages, while in one set of data the method of selection was to take a random sample of women who had, and of women who did not have, an accident during a particular month. It must be noted that the last-mentioned method, although indifferent if accidents are truly random, is not indifferent if the true cause be varying personal liability; on that hypothesis such selection is differential.

TABLE I.A.*—750 WOMEN WORKING ON 60-LB. SHRAPNEL

Accidents	*No. persons*	C.D.	B.D.	U.D.
0	398	422	411	429
1	294	242	258	233
2	43	70	67	70
3	10	14	12	15
4	3	2	2	3
5	2	.23	.01	.4
Total	750	750	750 (P=002)	750 (P=0)

* The meaning of the quantity P given in the first 10 tables is this: When a hypothesis requires the numbers of observations falling within a series of classes to be a_1, a_2, a_3, etc., and one actually finds b_1, b_2, b_3, etc. observations in these classes, the probability of the discrepancies having arisen by "chance" depends upon the value of the sum of such quantities as:—$\frac{(b_1-a_1)^2}{a_1}$, and is denoted by the letter P. For instance, in Table II., Shop A, P = .13 for the B.D. distribution means that were the hypothesis valid, then in every 100 trials we should get no better agreement than actually observed here 13 times. But for the U.D. hypothesis, the chance is better, viz., 39 in 100.

A glance at the tables is enough to show that the C.D. hypothesis is altogether inadequate, while in a majority of cases the other two hypotheses provide good fits; but on a general review of the data (Table X.) it is apparent that the U.D. method is decidedly superior. In five cases the B.D. distribution fails, the U.D. only twice (it is noteworthy that two sets of data which neither hypothesis fits are mere enumerations of totals employed and therefore the guarantee of equal exposure to risk is much slighter than in other cases). The superiority of the method of Unequal Liability is not a mere consequence of using a formula with one more constant; two moments are involved in each calculation; hence it appears just to infer that the hypothesis of the deviation from simple chance being dependent upon unequal initial liability to accident is sustained. We now proceed to examine the point more strictly.

It is evident that if the C.D. principle held, the previous record of any individual

TABLE X.

Data	*Values of* P	
	B.D.	U.D.
Random sample of 201 women	.60	.15
Random sample of 198 women	.22	.39
62 women having accidents in February	.94	.93
136 women having no accidents in February	.16	.17
55 women having accidents in January	.35	.89
61 women having no accidents in January	.90	.87
50 women having accidents in March	.00	.56
50 women having no accidents in March	.44	.39
648 women working on 6-in. H.E. shell, "A" shop	.13	.39
584 women working on 6-in. H.E. shell, "B" shop	.30	.16
100 women on machine work	.00	.48
414 women on machine work	.00	.57
750 women on 60-lb. shrapnel	.002	.00
580 women on 6-in. H.E. shell	.001	.002
Average of P	.29	.43

would be without influence upon his or her subsequent experience, just as if in one particular set of tosses a certain coin fell heads five times running, that coin would be neither more nor less likely to fall heads five times in a subsequent experience.

But if some one coin were biased in favour of falling heads, then its records in successive experiments would naturally be interrelated. Having in some of our data records of previous experience, we can easily determine which case responds to the reality, and in Tables XI.-XIII. are set out the records of women who in a particular month did or did not have accidents. It will be seen that almost invariably the balance of accidents is heavily against those women who fell victims in the month taken as a criterion of classification.

A yet more striking result is shown by other data which we owe to the zeal of some welfare supervisors in a great National Factory. These data were compiled with exceptional care and relate to random samples of women whose accidents, output and lost time over a trial of three months were carefully recorded, and whose accident experience in the previous three months was likewise available. We first went through these data rejecting all women who had not been in employment at the factory at least eight months when the record was made and we likewise rejected those who had been absent from work 14 days or more during the trial period. There remained 22 in one and 21 in another shop (the samples related in each case to women employed throughout the trial period upon one and the same lathe operation). We then correlated the individual's accidents in the two successive periods of three months. Tables XIV. and XV. exhibit the results from which it appears that in both processes the correlation is substantial and especially noteworthy in the sample of heavy lathe operatives, who were performing what is considered to be a strenuous task. Tables XVI. and XVII., covering all the records, tell the same story.

Since there is considerable correlation between the records of successive periods, there can be little doubt that the C.D. hypothesis is inappropriate. To discriminate between the two other suppositions a further investigation is necessary. Upon either hypothesis we should expect to find correlation, but, were the B.D. hypothesis correct, the observed correlation would be increased by eliminating from the record individuals who sustained no accidents in the first period because, *ex hypothesi*, these persons are neither more nor less likely to have accidents in the second period than they were before; hence their presence amounts to a dilution of correlated pairs with uncorrelated pairs. On the other hand by the U.D. hypothesis there is correlation between immunity in one period and immunity in the following period. Accordingly if we remove the pairs the first members of which are zeros, the correlation should increase if the B.D. hypothesis is correct, but not otherwise. Table XVII.A shows that in every instance the correlation is reduced, although the difference is hardly significant. The conclusion, then, is that the supposition of unequal initial liabilities better explains the facts, as was suggested by the previous investigation.

These results indicate that varying individual susceptibility to "accident" is an

TABLE XVII.A.—CO-EFFICIENT OF CORRELATION BETWEEN ACCIDENTS IN SUCCESSIVE PERIODS

Data	*Observed 3 months and previous 3 months*	*Not including persons having no accidents in previous 3 months*
Women on heavy lathe operation	.69 ± .06	.63 ± .09
Women on heavy lathe operation engaged in 1917 or earlier	.72 ± .07	.61 ± .12
Women on profiling operation	.53 + .09	.37 ± .14
Women on profiling operation engaged in 1917 or earlier	.37 ± .12	.18 ± .17

extremely important factor in determining the distribution; so important that given the experience of one period it might be practicable to foretell with reasonable accuracy the average allotment of accidents amongst the individuals in a subsequent period (Table XVIII.) This result is in itself of considerable interest, because it shows that by weeding out susceptibles the accident rate would necessarily decline; but before much practical value attaches to it we must be a little clearer as to what one ought to mean by this phrase individual susceptibility.

The naive interpretation is of course that of carefulness or carelessness; as one says, there are people whose fingers are all thumbs and there are others who are neat fingered; or again some people are scatter-witted and others circumspect; do our results amount to more than an arithmetical verification of this? Perhaps not, but there are other possibilities. Industrial accidents are usually held to be a function of output, and also a function of fatigue; the faster one works the greater the number of accidents, and the more weary one is when working at the same rate the greater the risk of misadventure.

We naturally ignore in this investigation any effect of *general* increase of output or of *general* fatigue due to conditions affecting all, but individual variations do concern us. Then again, our records of accidents are of *reported* accidents and, with few exceptions, the accidents are trivial, small cuts, slight burns, foreign bodies in the eye, rarely involving either absence from work or recourse to a surgeon. But the nervous or ultra careful woman may, for various reasons, report accidents which the average woman would disregard altogether. Consequently we have sheltering under the term individual susceptibility a motley host of motives or factors which will be very difficult indeed to separate and measure. Two variables, however, we can attempt to deal with, viz., output and general sickness.

Tables XXI.-XXIV. relate to the women used in Table VIII., and the records of broken time were not so accurate as we could wish; they show no measurable difference of output between the women who had and those who did not have accidents.

Tables XXI-XXIV. relate to the women figuring in Tables XIV.-XVII., and here the records of lost time were more satisfactory. Output has been reduced to terms of hours actually worked. It will be noticed that the heavy lathe operatives and the profilers vary in opposite directions; but in view of the absolute smallness of the divergences, and paying attention to the error of sampling, we do not think any stress can be put upon the result; so far as our data go the differentiation of those who do, from those who do not, have accidents cannot be shown to be related to a similar differentiation in the matter of output. Those who sustain many accidents are on the average neither less nor more productive workers than their fellows.

In Tables XXV. and XXVI. time lost by sickness is brought into relation with the accident record. Here there is, perhaps, some indication of a difference, sickness lost time being negatively correlated with accidents. But, as Professor Loveday pointed out, the allocation of lost time to different causes is, unless medical certificates of a trustworthy character are available, extremely unreliable, so that the relation may mean little more than a tendency to credit some sickness or lost time to accidents among women who have had accidents, the real attribution being uncertain.

Accidents have also been correlated with age (Tables XXVII. and XXVIII.), but the results again are of no practical importance.

In Tables XXIX. and XXX. the accident data are tabulated by civil state; no significant difference can be detected.

It is of course evident that the investigations detailed in the last paragraphs will need to be repeated upon much larger numbers of observations before the negative conclusions suggested therein can be taken to be demonstrated. But, so far as our present knowledge goes, it seems that the genesis of multiple accidents under uniform external conditions is an affair of personality and not determined by any obvious extrinsic factor, such as greater or less speed of work. We cannot say that the victims are less healthy persons than those who escape, or that they are better workers — so far as our data go there is no reason to think that they are especially productive workers. If this conclusion be confirmed by a wider investigation the practical corollary is obvious. The "susceptible workers" should be transferred so far as practicable from processes involving any special risk of accident to occupations not exposing to any such risk.

It is perfectly true that, in the particular occupations we have studied, the accidents are rarely serious, and, according to our results, do not lead to a deterioration of either general health or output. This inquiry was not undertaken for the sake of those occupations alone but in the hope of throwing light upon the general problem. Naturally we chose branches of a trade in which accidents were usually trivial, as otherwise we should have had grave difficulties in securing approximate equality of exposure to risk in different classes. The point is that with such material, we can determine whether accidents are randomly distributed like the fall of dice, and we have seen how the distribution diverges from that type.

The law of a *distribution* will not in general be affected by the consequences attaching to the results. The number of sixes thrown with a pair of true dice in a hundred trials will not be affected by the height of the stakes. Hence if we are warranted in referring the distributions here discussed to the factor of individual susceptibility we can have no hesitation in thinking that the same principle may apply to the genesis of accidents the results of which whether to the individual or to the plant may be grave. We should indeed expect that the *gross number* of accidents would be reduced, but their proportional distribution, as between individuals, might well remain the same. The consequence attaching to an accident will in fact change the absolute but not the relative scale, precisely as would alterations of any other factor (such as varying the temperature) affecting all the employees.

There are some industries—branches of the explosive supply trades for instance—in which accidents may lead to frightful disaster; nine times out of ten, perhaps 99 times out of a hundred, a trivial cut or scratch is the sole consequence; the tenth or the hundredth time the consequence is appalling. In our view, the results here described point a moral. Trivial accidents are indicators of unsafe people whom the record of the ambulance room can be employed to discover.

What numerical criterion of special susceptibility should be adopted is not an easy question to answer. A rough rule would be to reckon within this category all workers who during an accounting period, say, of a month, are shown by their records to have sustained more than twice the number of accidents per head of the average over all operatives in the particular department. It is to be noted that the criterion should refer not to the severity but to the frequency of the accidents. From the present point of view a worker who has had three trivial accidents is a more dangerous person than one who has had a single bad wound.

More than 40 years after publication, this article is still the clearest statement of the concept of accident proneness, in terms of its carefully marshaled evidence and its analysis of the underlying assumptions. Perhaps even more important in view of their

subsequent neglect is the attention given to: (1) the selection for study of groups with equal exposure; (2) problems relating to completeness of reporting; (3) spurious factors; (4) the meaningfulness of variables; (5) the types of accidents studied; and (6) the predictive value of the findings. Nonetheless, it is important to note that the conclusion—"so far as our present knowledge goes, it seems that the genesis of multiple accidents under uniform external conditions is an affair of personality. . . ."—was essentially a diagnosis of exclusion reached in the absence of any study of the personalities of those whose accidents were tabulated. In view of the limited number of characteristics of the workers available for study through the secondary sources employed, this stands as a highly questionable conclusion; its apparent validity has been increased by its frequent citation out of context.

A CONTRIBUTION TO THE STUDY OF THE HUMAN FACTOR IN THE CAUSATION OF ACCIDENTS

—E. M. Newbold

In 1926, Newbold, following up the preliminary work of Greenwood and Woods, studied the accident records of a large group of workers in 13 factories. Although her results largely substantiated those of Greenwood and Woods, she was careful to point out that "It is not possible in a mass examination of this kind to find out how much of this may be due to individual differences in the conditions of work or how much to personal tendency, but there are many indications that *some* part, at any rate, is due to personal tendency." Nonetheless, despite Newbold's caveat and her careful phrasing with respect to "personal tendency," her work has been widely cited as offering definite proof of the existence of individuals who are *psychologically* prone to accidents. Such citation probably resulted in part from her conclusion that:

> The indications of individual differences seem to be definite enough to justify the further more detailed investigation on the lines of individual study and experimental psychology which is now being carried on,‡ rather than on the lines of the present report. The present results show that it is clearly necessary in such study to take age and health into consideration.

Partially as the result of this statement, the idea of accident proneness—together with the belief that the best attack on industrial accidents is the detection and elimination of accident-prone workers—was to dominate industrial psychology for some time.

In almost all the groups studied, Newbold found, as did Greenwood and Woods, that a small number of workers contributed more than their share of accidents. This could be attributed both to individual differences in conditions of work and to personal tendencies. The accident rate was found to decrease with age and with length of service. Of considerable significance in establishing this personal tendency as a stable factor was the finding that accident occurrence for given individuals was consistent (1) in different time periods, (2) for accidents of different types, and (3) in the factory and at home. These findings were equally applicable to men and women.

‡ See Farmer and Chambers, below.

The original report consists of 75 pages and includes 30 detailed tables and 7 graphs that are models of statistical sophistication. Space considerations limit us, however, to the reproduction of several typical tables and only the most germane parts of the text.

1. Introduction

The conditions of our present civilization tend more and more to make it possible for an accident arising from some trivial cause to involve many in disaster. It is not, however, those accidents which most strike the imagination which are best adapted to the study of the cause and prevention of accidents in so far as this may be related to the human factor. For such a study we need a large number of observations both of accidents and of freedom from accidents, *i.e.*, we want to observe a set of people exposed as far as possible to the same risks and to other conditions, some of whom have accidents and some of whom do not, and see what associations we can trace among them. To get anything approaching to such conditions we have confined our present observations to industrial accidents. But this does not preclude the application of any results or suggestions that may arise to the problem of the determination of the fitness of an individual for any position involving special risk to himself or other people. In dealing with the human factor we do not intend in the least to minimise the importance of the mechanical side of accident cause and prevention, or to show any sympathy with the neglect of the first and most clearly necessary duty of any employer to make all machinery and working conditions as free from risks and as foolproof as possible. Foresight and ingenuity in that direction can go a long way, but very little study of the reports of industrial accidents is enough to show that the best devised safeguards cannot cover the whole field. It is repeatedly pointed out in the Annual Reports of the Chief Inspector of Factories that the great bulk of accidents are not caused by machinery and only a relatively small proportion can be prevented by mechanical safeguards. He estimates that the accidents due to machinery represent rather less than one-third of the total, though there is no doubt that they include a high proportion of the more serious accidents. . . .

The cause of an accident is hardly ever simple; it may be mechanical, physical, physiological, psychological, or more probably a combination of some or all of these. The value of mass statistics applied to such complex or, indeed, to any psychological happenings has often been called into question. Even today one meets with the same criticisms as were raised more than a hundred years ago when Laplace, Poisson, and Quetelet first began to apply numerical treatment to the psychological and sociological questions comprised under their term "choses morales." These criticisms, so far as they are relevant to our present work, are usually based on the following grounds: (1) the complexity of the causes which are due to the human element; (2) the triviality of the events dealt with (our accidents here are for the most part slight cuts, bruises, burns, etc.); (3) that accidents—serious or trivial—are just "accidents," and might happen to anyone at any time, and are subject to no law.

The answers today to such objections are the same as were given then; firstly, that there is no essential difference except in increased precision (made possible by suitable notation) between mathematical and any other logical method of reasoning, or as Laplace put it "La théorie des probabi-

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lités n'est, au fond, que le bon sens réduit au calcul." The very complexity of the causes into which the human element enters is a reason *for* rather than *against* analytical treatment. "La société n'est pas comme un instrument de physique, qu'on arrange ou qu'on dérange à son gré, pour l'étudier sous toutes ses faces, dans tous ses rouages et sous le jour le plus favorable. . . . On ne peut donc pas, comme dans la plupart des sciences d'observation, rendre égales à volonté toutes les causes influentes moins une, pour étudier les effets et le mode d'action de cette dernière. Souvent il faut procéder par d'autres voies; il faut substituer l'analyse à la synthèse, et commencer par prendre le phénomène dans son état le plus général."

The charge of triviality of the data would have some foundation if these minor accidents were themselves alone the subject of our enquiry. We look on them rather as some measure—inadequate though we know it to be—of a rather vague quality which we will examine more closely as we go on, and which we may call "tendency to accident." Such a tendency leads to certain events: in 99 cases out of 100, say, the consequences of these events may be of little or no importance, in the hundredth they may be disastrous; hence the seriousness or triviality of the consequences bears in general no relation to the exciting causes; we may take as an index of the existence of potential causes of dangerous events any results of such causes quite irrespective of their importance in themselves.

We now come to the third objection—that accidents follow no law. The principle of statistical stability has been defined by Poisson. . . .

. . . That accidents do exhibit statistical stability has been illustrated by Collis and Greenwood, not only as regards absolute numbers and age distribution of fatal cases, but also in the distribution according to cause and to the part of the body affected in non-fatal accidents, and as described below we find evidence of the same quality also in our present observations of the most trivial accidents.

* * *

. . . The present paper is only meant as a preliminary clearing of the ground by making as much use as possible of the mass statistics of individual information that are obtainable without special experiment in the normal course of the work in a well-organised factory, and it is ancillary to the more detailed individual experimental work which is being carried out by Mr. Farmer. It is clear *a priori*, and in doing the present work the point has continually forced itself on us that the scope of the mass examination of the sort of material dealt with here is limited, and that a study of the individual factor in accident causation calls rather for more work along the lines of individual study and experimental psychology (which is outside the province of the present writer) than for an extension of the statistical side of the work. This limitation is not meant, however, to apply to the use of accident statistics of this kind by individual factories, where the necessary details relating to the conditions of work and of the workers are either known or can be readily ascertained. Careful study of such records in different departments either along the lines followed here or in other fuller ways which may be possible in individual cases, would probably often define more closely the profitable field of preventive measures. On the whole, the results of the present inquiry show that a high accident average in a department is usually traceable to a relatively small proportion of those employed, and that *part*, at any rate, of the cause is personal rather than mechanical. In cases where the distribution is clearly not a chance one, very little observation in the workshop by anyone thoroughly familiar with the work, or perhaps an experimental interchange of occupations or machines among workers, would soon decide whether the cause was mainly personal or mechanical, and so point if necessary to the remedy. On the other hand, a high accident average, combined with a chance distribution among the workers, would point to causes inherent in the conditions of the work and affecting all alike.

2. Description of Data

The original aim of the present investigation was to examine the incidence of accidents in different industries with special regard to the following points, so far as these can be determined from factory records without special experiment: (1) the possibility of establishing in different occupations a characteristic ratio between the frequency of accidents of all kinds and notifiable accidents; (2) the question of the extent of the existence of individual workers having a distinct tendency to incur accidents; (3) the statistical correlation of accident incidence with age, sex, experience, health, output, etc.

A large number of firms, covering many different industries, were visited and their accident records inspected, and it soon became clear that the ratio of notifiable accidents to accidents of all kinds would not be comparable from firm to firm and from year to year, not only because of the great difference in the risk of trivial accidents in different processes of the same occupation, but also because with improving conditions two factors are acting in opposite directions on the figure for the number of accidents of all kinds: (1) Their *actual* number tends to decrease with improved conditions.[1] (2) Their *reported* number tends to increase owing to greater strictness about reporting trivial injuries, to improved First Aid facilities, and sometimes to the introduction of compensation paid over and above statutory compensation.

Consequently this point was dropped, and attention devoted to the question of the existence of individual tendency and the association of this tendency with other qualities. For this purpose, since large numbers of individual records were needed, it was clearly useless to deal with serious accidents alone; also, as already mentioned, a trivial accident will serve for our present purposes (which are concerned with the tendency to accident rather than the consequences), as well as a more serious one. (For this point, see also Section 10.) In this report, therefore, "accident" denotes any injury, however slight, which is recorded as treated either in the Ambulance Room or from Ambulance Boxes.

Out of many factories visited, twenty-two were chosen as being suitable, and willingly undertook to keep records. In a few cases the past record could be used, but in most cases records have been specially kept for us on individual cards. . . . The periods covered vary from three months to two years, the total number of workers observed was 8,962—6,938 men and 2,024 women, and the number of accidents 16,188. . . . The choice of firms and departments was guided by: (*a*) opportunity for many small accidents; (*b*) homogeneity of work done; (*c*) strict reporting of all trivial accidents.

The manufactures include: electrical apparatus, textile machinery, motor cars, optical instruments, general engineering, soap and glue, india-rubber articles, sweets, chocolates, ammunition, brass and copper articles, wooden boxes, cardboard boxes and tin boxes.

The information that it was found possible to get for individual workers was: age, sex, length of time in the factory, number and type of accidents, visits to the Ambulance Room for minor ailments, time lost for sickness, accident, lateness, and other causes, and occasionally output.

* * *

Stress must be laid on the fact that no comparison as regards the average number of accidents should be made from one group to another; the conditions are quite different, and such a comparison would lead to no useful result. Our aim has been rather to take each group separately, and examine the distribution and associations *within* that group, and then see what points are common to many groups. In dealing with variables in which the social or human elements can enter largely, it is often not possible to get any single homogeneous group big enough

[1] For instance, in a department employed on packing soap tablets in wooden boxes each girl used to nail up her own boxes as she packed them; this resulted in a large number of hammered finger tips, etc. The work was rearranged so that one or two girls did all the nailing for the rest, and these accidents practically disappeared.

for an association which is not quantitatively large to appear significant with regard to its probable error, but a number of consistent results from different groups, even if the sampling errors are large, inspire some confidence in their stability. . . .

3. Distributions of Accidents among the Workers

To avoid a wearisome description, the main preliminary facts about the different groups have been set out in tabular form in Table I, not for comparison one with another as regards the number of accidents, but to give a general idea of the nature of the group, etc. Our first aim is to examine individual differences *within* each group, so that to begin with we will take the mean number of accidents observed in each period as an accepted fact, characteristic of the nature of the work, and then study the distributions among the workers, bearing in mind the remarks in the last section about the amount of apparent homogeneity attained. Given a certain average, what sort of distribution would be expected assuming all were exposed to exactly equal risk and the differences simply arose from sampling? That is, how many people should we expect to find with 0, 1, 2, etc., accidents, there being no special reason why any one should have more than any other. These numbers are given by the successive terms of Poisson's exponential series. . . .

* * *

It is very clear from these graphs that our groups are not homogeneous as regards accident risk. We can, of course, never hope to establish the truth of a hypothesis by the accuracy of fit of an observed series with the theoretical distribution calculated on the basis of the hypothesis. Even with very large numbers, excellent fits can be obtained with series based on quite incompatible hypotheses. Such comparison, nevertheless, may be extremely useful to show either that a given hypothesis does *not* hold, or that it *might* hold, and, on the assumption that it does, to see what sort of values would be obtained for constants involved.

Two other hypotheses relevant to accident distributions were discussed by Greenwood and Yule in the paper quoted above. The first of these assumed that the liability to accidents is altered by having sustained an accident; the series from which the numbers having 1, 2, . . . accidents can be computed is

$$\frac{N}{s}\left(\frac{N-s}{N}+\frac{s}{N}\right)^n$$

omitting the first term, where s is given by

$$\mu_2 = \frac{n\{N-n+s(n-1)\}}{N^2}$$

N = Number of people.
n = Number of accidents.
μ_2 = the second moment of the accident distribution.

When s is greater than unity it denotes an

Table I.—Nature of Groups Observed as Regards Occupation and Accidents (Males)*
(Period of Observation: Jan. 1 to June 30, 1922)

Factory Group	Nature of Occupation	Mean No. of Accidents per Person in Period	Standard Deviation	Observed Coefficient of Variation	C. of V. of Poisson with Same Mean	No. of Persons Observed	No. of Accidents	No. of Accidents per Worker per Year (Approx.)
	Making and assembling motor cars (metal departments):—							
A I	All departments with mean number of accidents, 5 or over	6.44	6.47	100.6	39.4	204	1,313	12.87
A II	All departments, under 5 but not under 3	3.78	4.14	109.6	51.4	352	1,330	7.56
A III	All departments under 3	2.56	3.25	127.1	62.5	304	777	5.12

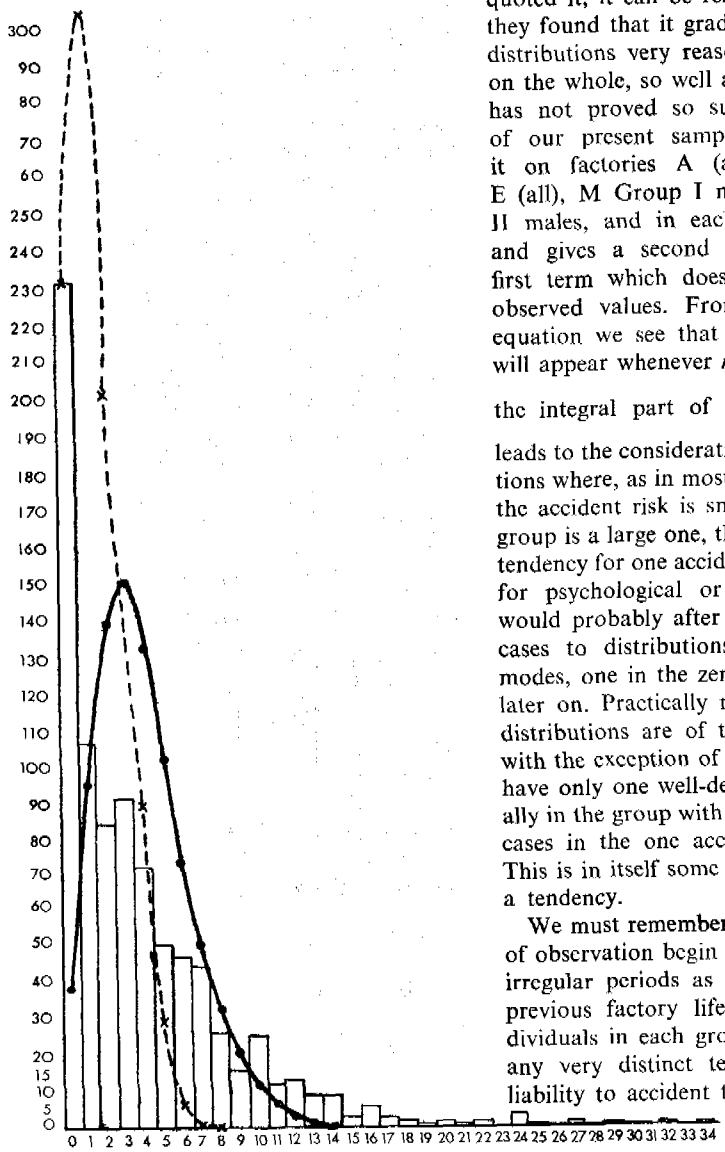
* We have reproduced only the first part of this table showing Factory A. Eds.

increased liability after the first accident. The group having no accidents is equal to

$$\frac{N}{s}\left(\frac{N-s}{N}\right)^n + \frac{N(s-1)}{s}$$

The writers concluded that the theoretical basis of this biased scheme was not appropriate to the present problem, and that at best it could only give a good smoothing formula. In the simplified form in which we have quoted it, it can be readily employed, and they found that it graduated some of their distributions very reasonably, though not, on the whole, so well as a third scheme. It has not proved so successful with those of our present samples. We have tried it on factories A (all), B (all males), E (all), M Group I males and M Group II males, and in each case it fits badly and gives a second maximum after the first term which does not appear in the observed values. From the form of the equation we see that this later maximum will appear whenever $n - 1$ is greater than the integral part of $\frac{(n+1)(N-s)}{N}$. This leads to the consideration that if in distributions where, as in most of the present cases, the accident risk is small, so that the zero group is a large one, there were any general tendency for one accident to lead to another for psychological or other reasons, this would probably after a time lead in many cases to distributions with at least two modes, one in the zero group and another later on. Practically none of the observed distributions are of this form; almost all, with the exception of Factory A, Group II, have only one well-defined maximum, usually in the group with no accidents, in a few cases in the one accident group or later. This is in itself some evidence against such a tendency.

We must remember also that our periods of observation begin at quite arbitrary and irregular periods as regards the length of previous factory life of the different individuals in each group, and if there were any very distinct tendency for increased liability to accident to those who had one



FACTORY A. WHOLE FACTORY

GRAPH I. Accident distributions, males, compared with theoretical chance distributions.

or more, we would naturally expect to find some tendency on the whole for those who had been longer in the factory (and so had more opportunity for previous accidents, before our period of observation began) to show increased liability to accident. This is not, however, the case; what correlation there is between accidents and length of previous employment in the factory is, in the great majority of cases, in the other direction, i.e., the people with most accidents have, on the whole, been a shorter time in the factory (see Section 4 below).

The third scheme discussed by the same authors was one arising from the theory of an unequal distribution among the workers of susceptibility to accidents. The simplified form they adopted was based on the assumption that this distribution was continuous and of the form $y = y_0 e^{-c\lambda} \lambda^{r-1}$ where λ is the measure of liability, or susceptibility, and c, r and y_0 constants. The resulting accident distribution is fitted from the mean and 2nd moment about the mean of the distributions observed. They found on their data from women workers in munition factories that this scheme gave a better fit than either the pure chance or the biased scheme. We have tried this on some of our larger groups with the same result. . . . In those groups, which are made up of more than one department, we have taken as the pure chance theoretical distribution the sums of the Poissons fitted to the means of each department separately. Very few of these equal liability distributions, as we have already seen from graphs I and II, give at all a reasonable fit, and some entirely fail to get the general shape of the observed groups. The unequal liability theory (denoted in the tables by (51) and (52)) is in all cases a great improvement on the Poissons. It is still far from a very good fit in some cases, but by combining some of the groups the results on the whole are fair, as tested by Pearson's Goodness of Fit Test. To sum up these results I think we can say that, though it clearly does not give the whole truth, the assumption of this particular arbitrary smooth distribution of individual susceptibility among a body of workers, ignoring the different risks in different departments, gets considerably nearer the truth than does ignoring individual susceptibilities and taking account only of different risks in different departments. This is a noteworthy point, as in some cases the differences in the mean number of accidents in different departments is very sharp. The association between the department in which the worker was employed and the number of accidents he (or she) had as measured by the correlation ratio has been found in a few cases, and is of about the order .4.

Factory	*Correlation ratio between department and no. of accidents*	*No. depts.*	*No. people*
A. Males	.306 ± .021	18	860
B. Males	.363 ± .028	26	447
B. Females	.397 ± .035	14	267
E. Males	.463 ± .009	58	3,601

Here again, of course, we must remember that so far as the distributions go, "individual susceptibility" may mean susceptibility due to some conditions in the individual's work which he does not share with the others just as well as personal tendency. In the following sections we shall go into this point, and there are many suggestions that the part played by the personal factor is not unimportant.

* * *

4. Relation of Accidents to Age and Experience

It is the common experience in analyses of accident records to find that with the taking on of new men accident rates go up. As these times usually coincide with increased business activity, we find the higher rate sometimes attributed to the speeding up of output and sometimes to the inexperience of the newcomers, and it is often difficult from the published records to distinguish between these two factors. The apparent effect of inexperience is well brought out in the rates [top p. 405] for accidents causing loss of time in a large steel plant in America, January-May, 1916.

Similarly in a motor car factory and a fuse factory covering together 50,000 work-

TABLE II.—COMPARISON OF OBSERVED WITH THEORETICAL DISTRIBUTIONS, FACTORY A, MALES

WHOLE FACTORY

No. of accidents	NO. OF PERSONS: Observed		Calculated by[1] (51) and (52) (a)		Sum of Poissons[2] to departments (b)	
0	230		198.73		38.22	
1	105		137.52		94.04	
2	83		104.38		138.25	
3	90		81.55		149.29	
4	71		64.63		131.58	
5	50		51.65		101.98	
6	47		41.51		73.23	
7	44		33.49		50.24	
8	26		27.10		33.28	
9	16		21.98		21.25	
10	25		17.86		12.97	
11	12		14.54		7.53	
12	13		11.85		4.13	
13	9		9.66		2.14	
14	9		7.89		1.05	28.56
15	3		6.45		.49	
16	6	98	5.27	97.46	.21	
17	3		4.31		.03	
18	2		3.53		.01	
19	1		2.89			
20	2		2.37			
21	1		1.94			
22	2		1.59			
Over 22	10		7.31			
	860		860.00		859.92	

(a) For 11 groups as by right hand brackets. $\chi^2 = 24.24$, $P = .007$
For 8 groups as by left hand brackets. $\chi^2 = 7.42$, $P = .388$

(b) 1245.5 $< .000001$

1 On the theory of differing individual liability.
2 On the theory of pure chance.

GROUP I

No. of accidents	NO. OF PERSONS: Observed			Calculated by (51) and (52) (a)		Sum of Poissons to departments (b)	
0	41	58		22.86	45.47	0.42	2.95
1	17			22.61		2.53	
2	10	21		20.75	39.30	7.61	23.01
3	11			18.55		15.41	
4	16	23		16.36	30.67	23.68	53.16
5	7			14.31		29.48	
6	18	36		12.45	23.24	30.99	59.31
7	18			10.79		28.32	
8	10	15		9.33	17.37	22.96	39.73
9	5			8.04		16.77	
10	11	18		6.92	12.87	11.17	18.02
11	7			5.95		6.85	
12	5	8		5.10	9.48	3.89	5.96
13	3			4.38		2.06	
14	6	6		3.75	6.96	1.02	1.50
15	0			3.21		.48	
16	4	5		2.74	5.08	.21	0.30
17	1			2.34		.09	
18	1	2		2.00	3.71	.03	0.05
19	1			1.71		.02	
20	1	2		1.46	2.71		
21	1		14	1.25			
22	2	2		1.06	1.97		
23	–			.91			
24	3	8		.77	5.17		
Over 24	5			4.40			
	204			204.00		203.99	

(a) For 13 groups $\chi^2 = 26.15$, $P = .010$

(b) For 10 groups $\chi^2 = 5049.1$, $P < .0000000$

Length of service	*Acc. frequency rates per 1,000 300-day workers*	*No. of 300-day workers*
6 months and under	111.3	512
Over 6 months and not over 1 year	104.3	278
Over 1 year and not over 3 years	86.8	357
Over 3 years and not over 5 years	42.4	637
Over 5 years and not over 10 years	19.7	814
Over 10 years and not over 15 years	8.5	470
Over 15 years	—	459
Total	46.5	3,527

ers it was found that the level of the accident rate varied inversely with experience of the workers, and though some of the methods in this report are open to criticism, this finding is in agreement with general experience. In such analyses however, when, as is usually the case, only one factor is considered at a time, the interpretation is doubtful.

Experience and age are naturally closely bound together, and it is likewise generally found that the older workers have as a rule fewer accidents than the younger ones when conditions of work are more or less alike (e.g., Chaney and Hanna, also Amy Hewes and Others, who in a study of accidents in a silk mill in Connecticut found that the accident rate decreased with age, that those under 20 had the highest rate, and also that the younger people tended to have more than one injury to a greater extent than the older ones). How far this tendency is due to general immaturity and how far to unfamiliarity with the particular job is not evident without a more detailed analysis. In our present study we have tried to choose periods in which there were no great changes as regards pressure of work, and by breaking up into small groups to make the work in each more homogeneous than is possible in the analyses which cover much larger numbers. Some attempt has also been made to separate the two factors of age and experience by using the method of partial correlation. We have only been partly successful in this as our measure of experience is limited to that of the particular occupation at the period of observation, and consists of the length of service in that particular factory, which in the great majority of cases means service in the same department; where this differed and the information was available, service in the department was taken. Experience in the same occupation but in other factories is thus left out of account.

The average age among the men in our data is naturally higher than among the women, 35 to 40 years is the most common mean age of the male groups and 19 to 22 years of the women (see Table VIII); and, in spite of the women's lower mean, their percentage variability is also smaller,

TABLE VIII.—AGE (IN YEARS) OF THE WORKERS IN THE VARIOUS GROUPS

FACTORY GROUP	MEAN	S.D.	COEF. OF VAR.
	Men		
A I	34.7	8.6	38.2
A II	34.0	9.1	26.8
A III	38.2	10.3	26.9
B I	36.7	15.3	41.4
B II	36.3	14.7	40.4
E I	29.8	11.8	39.6
E II	37.0	12.9	34.8
E IV	34.5	11.5	33.3
E V	39.4	14.7	37.3
E VI	40.0	12.8	32.0
E VII	39.6	12.7	32.0
F I	19.5	8.60	44.1
F II	30.1	9.01	30.0
G I	45.6	16.9	37.0
G II	42.1	15.4	36.6
I —	27.7	12.8	46.1
M I	22.3	7.0	31.4
M II	30.7	8.1	26.3
M III	25.9	9.47	36.5
M IV	36.4	11.5	31.7
M V	38.6	10.3	26.6
M VI	39.9	11.1	27.8
N —	33.9	13.1	38.6
	Women		
B I	19.8	3.6	18.4
B II	19.4	4.05	20.8
C —	22.9	5.7	24.9
D I	19.4	7.0	36.2
D II	16.2	1.52	9.37
G I	22.0	6.29	28.6
G II	25.6	11.7	46.0
H —	19.0	4.68	24.6
I —	22.7	5.75	25.3
K —	21.6	7.74	35.7
M I	23.0	8.7	37.8
M II	18.6	4.46	24.0
M III	19.1	5.71	30.0
M V	15.7	2.69	17.1

usually 25 to 35 per cent., as against 35 to 40 per cent. in the men. The length of service of the men is, on the whole, also longer (see Table IX), but there is not much difference in the variability in the two sexes; this is made high in some of the women's groups by the presence of a few old stagers, though the main body usually consists of young unmarried girls.

* * *

With only two exceptions among the women . . . the rate of accidents also goes down with both men and women with length of time in the factory, though not so decidedly as with age. It has not been thought necessary to reproduce these graphs.

A more exact idea of the force of these tendencies is given by correlation coefficients of age with accidents and length of service with accidents. . . . The distributions of the total coefficients are:—

TABLE IX.—EXPERIENCE (LENGTH OF TIME IN FACTORY IN YEARS)

FACTORY GROUP	MEAN	S.D.	COEF. OF VAR.
	Males		
A I	2.49	1.75	70.3
A II	2.40	1.71	71.3
A III	3.37	2.21	65.6
B I	9.09	10.80	118.8
B II	10.34	11.80	114.1
F I	1.15	.96	83.1
F II	2.28	2.88	126.5
G I	13.27	13.52	101.9
G II (*b*)	7.75	7.94	102.5
I —	.86	.88	103.1
M I	6.78	5.23	77.2
M II	6.99	4.32	61.8
M III	8.86	7.11	80.3
M IV	6.51	5.22	80.2
M V	15.39	9.49	61.6
M VI	8.68	5.80	66.8
N —	4.59	6.95	151.3
	Females		
B I	4.25	2.48	58.4
B II	3.53	2.22	62.8
C —	1.67	2.19	131.0
D I	1.82	1.61	88.5
D II	1.23	.78	63.7
G I	4.36	4.73	108.5
G II	5.60	6.77	120.9
H —	2.45	2.78	113.7
I —	.90	1.06	117.3
K —	3.76	4.96	131.9
M I	7.63	8.46	110.9
M II	3.43	4.05	118.2
M III	4.37	5.18	118.6
M V	1.32	2.12	159.7

CORRELATION COEFFICIENTS OF ACCIDENTS WITH (*a*) AGE, (*b*) LENGTH OF SERVICE

	(*a*) AGE		(*b*) LENGTH OF SERVICE	
	Males	*Females*	*Males*	*Females*
+.2 to +.1	0	0	1	0
+.1 " 0	0	1	0	2
0 " −.1	3	6	7	5
−.1 " −.2	9	4	8	6
−.2 " −.3	5	2	1	0
−.3 " −.4	3	1	0	1
−.4 " −.5	3	0	0	0
−.5 " −.6	1	0	0	0
	24	14	17	14

Age and accidents have a coefficient with its commonest value somewhere near −.2, for both men and women, which agrees with that found by Greenwood and Woods (−.19 and −.18) for women munition workers. In groups where the liability to accident is greater, the coefficient is naturally higher and rises to −.4 and −.5. Many of the smaller coefficients are not in themselves significant, but the general consistence of the values taken as a whole is in favour of the existence of a real association, though not a strikingly strong one. The connection between length of service and accident is slighter, the most common value of the total coefficient is −.1, and here still more it is rather the whole distribution than the significance of single values that suggest any real association.

To compare the relative effect of age and length of service we pass to the partial coefficients, . . . and note that when age is kept constant, the association between length of service and accidents practically vanishes, being as often positive as negative and in almost all cases insignificant. On the other hand, when length of service is kept constant very little appreciable change is made, on the whole, in the relation between accidents and age, and the same is true when allowance is made for the possible disturbing influences of varying length of exposure, etc. The association between accidents and age is therefore the stronger

tendency, and has an independent existence, which cannot on these data be shown between accidents and length of service. We must remember, however, that our groups do not contain many absolutely new workers, and it is these, as a rule, who seem to be responsible for the sudden rises in accident rates with increased trade.

It may be that part of the association between accidents and age is due to selection, i.e. that the younger workers with liability to accident get weeded out, but the fact that the association still remains when length of service is kept constant suggests that this is not a very important factor.

The possibility of a greater willingness to report trivial accidents among the younger workers must be considered, and it may be noted that one of the causes suggested by the Factory Inspectors for the increase in reported (which means more serious) accidents in 1923 over 1922 is "anxiety on the part of elderly men to preserve their employment and full wages, resulting in their concealing trivial injuries until compelled to be off work by sepsis." In our present data, though we cannot hope to have entirely eliminated unreported accidents, we have tried to escape them by careful choice of factories, and one sign that this source of error is not very great here is the fact that all tendencies shown by our figures appear comparatively strongly in Factory A, which had the strictest system of penalties for any unreported trivial accident, and where a full-time Safety First Official made this point his special duty. Another sign is the agreement with the American results quoted above for more serious accidents. In English publications accident rates at ages are not easy to find. It is a generally accepted opinion that older people are more careful than younger ones, and it may seem superfluous to show in such detail that this is supported by the fact that they have fewer accidents, but even a crude numerical measure of any fact, however familiar, is better than no measure at all, and these figures may serve to lay stress on the obvious importance in any potentially dangerous occupation, of giving special definite instruction to young and inexperienced workers and so following the example of the mining industry which is making special efforts in this direction. At the same time, the possibility of a radical psychological difference in the attitude of workers to environments capable of producing minor and serious accidents is not to be overlooked, and this point is discussed later in Section 9.

* * *

9. Stability of Individual Incidence

If any practical meaning is to be attached to the tendency to individual susceptibility, we need to see how far this quality is a stable one. Greenwood and Woods, in the report quoted above, found that in four groups of women munition workers those who had accidents in one three months' period were more likely to have them in the following three months' period; the correlations they found were from .37 ± .12 to .72 ± .07. Miss Allen and myself, on a rather larger body of 387 munition workers on machine operations among the unpublished data referred to above, found the correlation between their accidents in two successive five months' periods to be .61 ± .02. We tested this figure for possible spurious correlation due to combining operations by taking four smaller samples from them, each homogeneous in itself, viz.:—

	Correlation coefficient
29 women on rough turning	.71 ± .06
17 women on parting off	.56 ± .07
30 women on groove and bead	.56 ± .07
54 women on boring	.04 ± .09

Another test was made by combining these 150 women, using instead of each woman's actual number the ratio of this to the mean number in her operation and period; the result was .59 ± .03, hence showing that the correlation was not spurious. Coefficients of the same order were found for 39 women on parting off during a six months' period between the accidents in morning, afternoon

and night shifts. Two of these groups of munition workers, those on profiling and rough turning, were particularly liable to have accidents from flying particles of hot metal, which caused either eye accidents or burns on the face or other exposed parts of the body. The following correlations between these and other types of accidents[1] among 64 women in two successive periods of seven months and three months show individual susceptibility also in this particular type of accident which might at first sight be thought to be entirely of chance origin. In this particular munition factory great strictness was observed with regard to accident reporting.

Coefficients of correlation between the incidence on the same individuals of—

(1) Accidents due to flying particles in the two periods	$.59 \pm .06$
(2) Other accidents in the two periods	$.38 \pm .07$
(3) Accidents from flying particles in period A and other accidents in period B	$.56 \pm .06$
(4) Other accidents in period A and accidents from flying particles in period B	$.32 \pm .08$

The stability of susceptibility from one period to another is on the whole confirmed by our present data. We have only used for this purpose the groups covering the longer periods of observations.

Only the last two of these groups failed to show positive association, and these are among the females who give smaller values in all our correlation tables owing to the fact that they have on the whole fewer accidents in the periods observed, so that there is less scope for variation. It is of course true that in these data the possibility of spurious correlation due to some amount of varying risk is present and cannot be avoided, but in four groups of Factory M, two of men and two of women, we had an opportunity of testing the stability without this complication. In these groups, some of the workers were treated at the ambulance room for accidents received at home, and the number of any individual's "home accidents" shows a positive correlation with the number of his or her factory accidents (see Table XXVII).

[1] Correction was made for varying numbers of hours worked.

TABLE XXVI.—CORRELATION COEFFICIENTS BETWEEN THE ACCIDENTS OF THE SAME WORKERS IN TWO PERIODS

Factory group			Correlation coefficient	No. of people	Length of periods, in years (a)	(b)
D	I	Females	$.21 \pm .15$	19	2	$^5/_{12}$
D	II	Females	$.36 \pm .09$	42	2	$^5/_{12}$
E	I	Males	$.57 \pm .02$	445	1	1
E	II	Males	$.25 \pm .04$	288	1	1
E	III	Males	$.62 \pm .03$	226	1	1
E	IV	Males	$.20 \pm .04$	288	1	1
G	I	Males	$.36 \pm .09$	47	1	1
G	II	Males	$.57 \pm .05$	82	1	1
G	I	Females	$.53 \pm .04$	120	1	1
G	II	Females	$-.01 \pm .10$	50	1	1
H		Females	$.05 \pm .05$	227	$^1/_2$	$^1/_2$

The correlation is positive in all four cases and of the order .2 to .3.

"Tendency to report" might, of course, play some part here, too, and no measure of this can be obtained. Another possibility that suggested itself for this correlation was that the home accidents might only be treated when the worker happened to be in the ambulance room for some accident received in the factory, but comparison of the dates shows that this is not the case. The same people who are unfortunate in the factory seem also to be unfortunate at home. This is only in accordance with ordinary experience, that though there may often be some element of truth in the excuse "the knife slipped" or "the plate came to pieces in my hand," there is usually a much larger element of truth in the statement that there are some people in whose hands knives and plates are more likely to do this than in those of others.

10. MINOR ACCIDENTS AS A CRITERION FOR MAJOR ACCIDENTS

It may be objected that the trivial accidents dealt with here are no criterion for the incidence of more serious accidents. Since any minor accident, however small, might by a very small alteration in attendant circumstances or subsequent treatment become a major accident, there seems to be some *a priori* grounds for supposing that the individuals who are more liable to small accidents are also more liable to more serious ones. Unfortunately, in the present data the number of more serious accidents (which for

TABLE XXVII.—CORRELATION COEFFICIENTS BETWEEN THE INCIDENCE ON THE SAME INDIVIDUAL OF ACCIDENTS IN THE FACTORY AND ACCIDENTS AT HOME (FACTORY M)

	Group	Total coefficient	Exposure to risk	PARTIAL COEFFICIENT—KEEPING CONSTANT Age	Exposure to risk and age	Exposure to risk, age and experience
Men	I	.200 ± .037	.199 ± .037	.170 ± .038	.170 ± .038	—
	II	.213 ± .033	.207 ± .033	.201 ± .033	.195 ± .033	—
Women	II	.261 ± .050	.223 ± .051	—	.222 ± .051	.236 ± .050
	III	.311 ± .051	.307 ± .051	—	—	—

present purposes we have defined as accidents causing lost time) is so small in the periods observed that they give no definite statistical evidence on this point, so that, until more figures are available, it must remain mainly a matter of opinion. Mr. Farmer has, however, collected a large amount of material from dockyard accidents on this question which he is now analysing.

* * *

12. SUMMARY AND CONCLUSIONS

(1) The reported ambulance-room accidents (whether trivial or serious) have been examined in a number of groups of factory workers covering different occupations, for periods of time varying from three months to two years.

(2) It is found that in almost all the groups the average number of accidents is much influenced by a comparatively small number of workers, and that the distributions among the workers are far from chance ones.

(3) It is not possible in a mass examination of this kind to find how much of this may be due to individual differences in the conditions of work or how much to personal tendency, but there are many indications that *some* part, at any rate, is due to personal tendency.

(4) A table is given . . . by which a rough estimate can easily be made from the accident records of a department, whether the causes of accidents are mainly such as affect all the workers alike, or whether special risk is attached to any individuals. If the latter is the case, it rests in the hands of the factory officials, familiar with all the conditions of the work, to see how far the cause is mechanical or personal.

(5) Typical accident distributions are described and fitted to some theoretical curves based on different hypotheses. The hypothesis that the occurrence of one accident makes the occurrence of others either more or less likely does not fit these observations. The particular hypothesis tested of differing initial individual susceptibility is nearer the truth, but clearly other factors come in.

(6) There is a tendency for the number of accidents to decrease to some extent with age and apparently also, though to a less extent, with length of service in the factory, but when allowance is made for age, there is no independent association between experience and accidents; while when allowance is made for experience, the association between accidents and age remains.

(7) A decreasing accident tendency with age towards serious accidents is shown not to be necessarily inconsistent with the known higher accident mortality and invalidity rates among older workers, but the present data do not include enough serious accidents to establish any relation between the tendencies to trivial and to serious accidents.

(8) The people who have the most accidents are, on the whole, those who pay most visits to the ambulance room for minor sicknesses.

(9) The consistence of individual tendency to accident is shown by the association found between (1) accidents in two different periods, (2) accidents of one type and accidents of other types, and (3) accidents in the factory and accidents at home.

(10) No consistent relation is shown between accidents and output in the few cases where output records were available.

(11) The above tendencies are shown by men and women alike.

(12) In the one group of males, where

comparison between night and day work was possible, no difference of any importance was observed in the accidents.

(13) The indications of individual differences seem to be definite enough to justify the further more detailed investigation on the lines of individual study and experimental psychology which is now being carried on, rather than on the lines of the present report. The present results show that it is clearly necessary in such study to take age and health into consideration.

Like that of Greenwood and Woods, Newbold's report embodies qualities often lacking in current accident research. The detailed attention paid to exposure factors, to matching the individuals on personal characteristics, to determining the relative importance of specific characteristics, to including warnings about comparing work groups, to differences in reporting habits, etc. shows a mastery of scientific methodology that might well be emulated today. As we shall note later, the weakness of these early researchers lies not in their methodology or their statistical treatment but in their theoretical interpretation of the findings as indicative of a stable personality characteristic called accident proneness by later workers.

A STUDY OF ACCIDENT PRONENESS AMONG MOTOR DRIVERS

—E. Farmer, E. G. Chambers

Farmer and Chambers' attempt to show that unequal liability could be traced to significant differences in personality between the accident-free and the accident-prone individual represents a third step in the evolution of research. Greenwood and Woods in 1919 had established a statistical correlation; Newbold in 1926 had substantiated this finding for a number of groups and showed its relationship to certain demographic group characteristics; finally, in 1939, Farmer and Chambers attempted to show the meaning of these differential accident rates in psychological terms. By this time, they felt that they could safely state that "Accident proneness is no longer a theory but an established fact" [preface].*

Using motor vehicle accident records, Farmer and Chambers once again substantiated the fact that accidents do not distribute themselves at random. They then administered psychological tests to accident-free and accident-repeating groups in an attempt to determine personal characteristics that might explain the differences observed.

In the excerpts that follow, we have not reproduced the data on accident liability, stability, or demographic characteristics, since these are similar to those presented above. We present in full, however, the results of the psychological tests. These consisted of aesthetokinetic, intelligence, mechanical aptitude, and perseveration. Significant differences between the mean accident rate and scores on these tests were found only for one group in relation to the aesthetokinetic tests. The authors express dissatisfaction with the intelligence and perseveration tests but, rather than come to negative conclusions, they feel that other tests of these factors should be used.

* See Arbous and Kerrich, below.

* * *

PREVIOUS statistical investigations have shown that industrial workers exposed to equal risks were unequal in their liability to sustain accidents and that this unequal liability was a relatively stable phenomenon, manifesting itself in different periods of exposure and in different kinds of accidents. Previous psychological investigations have also shown that it is possible in certain skilled industrial occupations partly to predict by means of tests which workers will subsequently sustain a greater number of accidents than their fellows exposed to equal risks.

The present report is an account of an investigation on similar lines amongst omnibus drivers. The object of the investigation was to see if it were possible to measure inequality in accident liability among certain groups of motor drivers and if so, whether it were also possible partly to detect beforehand by means of psychological tests those most likely to sustain accidents.

The results, which are given in detail here, are similar to those arrived at in a study of certain groups of industrial workers, so that the available evidence tends to show that accident proneness is a measurable quality, manifesting itself among motor drivers no less than among industrial workers.

The data obtained in this investigation also served in an examination of the relation of transport accidents to age and experience, and allowed an analysis of hourly, daily, weekly and monthly variations in accident rate to be made. In addition to the results of the psychological tests, the report includes analyses of accident records supplied by an insurance company and by a haulage firm.

A laboratory experiment to determine speed of reaction in applying the brakes of a car was carried out. . . .

II. GROUPS OF SUBJECTS FROM WHICH DATA WERE OBTAINED

Groups Given Psychological Tests

Group A.—Number in group 166. Mean age $27\,^{11}/_{12}$. Age range $24\,^{0}/_{12}$ to $36\,^{5}/_{12}$. Accident records for 5 years.

These were London omnibus drivers. All had previous experience of motor driving but nevertheless they were given an intensive training in bus driving before they were allowed on the roads. When engaged they were given certain psychological tests, but the results of these played no part in their selection. They were examined medically and great care was exercised in their selection from this point of view. The standard of reporting accidents was high, so that trivial accidents as well as serious accidents appear in their records. . . .

Group B.—Number in group 398. Mean age $28\,^{6}/_{12}$. Age range 24 to 37. Accident records for 2 years.

The members of this group are similar to those of Group A, except that psychological tests were partly used in their selection.

Group C.—Number in group 86. Mean age $38\,^{5}/_{12}$. Age range 24 to 59. Accident records for 4 years.

Drivers of both omnibuses and trolley buses in a large industrial town. These men had varying lengths of driving experience when they were given the psychological tests.

Group D.—Number in group 67. Mean age $35\,^{5}/_{12}$. Age range 26 to 55. Accident records for 4 years.

Trolley bus drivers in a seaside resort. These had varying lengths of driving experience when they were tested. Their experience on trolley buses was practically constant, since the company changed from trams to trolley buses in a fairly short time and retained the tram drivers as trolley drivers.

Reprinted from Report No. 84, 1939, Medical Research Council, Industrial Health Research Board (Great Britain), with the permission of the Controller of Her Britannic Majesty's Stationery Office. Portions of the text, 18 tables, 4 figures, and 5 appendixes have been omitted.

Group E.—Number in group 174. Mean age $20\,^{9}/_{12}$. Age range 18 to $28\,^{3}/_{12}$.

Army drivers under training. These were given psychological tests at the beginning of their training. Since the period of training lasted only 12 weeks, the number of accidents incurred was insufficient to form a valid criterion for the tests. The results of their final examination in driving proficiency were obtained and compared with the performance in the psychological tests.

Groups Not Given Psychological Tests

Groups F.— Four groups of owner drivers of private cars insured in one of the big insurance companies. Records of the accident claims made by these drivers during three consecutive years were obtained for Group F1, and during one year for the remaining three groups. Some of the groups were from large towns and some from country districts. The numbers in the groups were:—F1, 2,242; F2, 743; F3, 1,722; F4, 893. Mean age 41. Age range 16 to 80.

Groups G.—Thirteen groups of drivers of heavy lorries, employed by the same firm but working in different districts. Mean age $37\,^{11}/_{12}$. Age range 21 to 62. Numbers in groups varied from 43 to 98, the total number being 969.

TABLE I.—GROUPS OF SUBJECTS

Group	No.	Mean age	Age range	Accident records
GROUPS GIVEN PSYCHOLOGICAL TESTS				
A	166	$27\,^{11}/_{12}$	$24–36\,^{5}/_{12}$	5 years
B	398	$28\,^{6}/_{12}$	24–37	2 ,,
C	86	$38\,^{5}/_{12}$	24–59	4 ,,
D	67	$35\,^{5}/_{12}$	26–55	4 ,,
E	174	$20\,^{9}/_{12}$	$18–28\,^{3}/_{12}$	12 weeks
GROUPS NOT GIVEN PSYCHOLOGICAL TESTS				
F1	2,242	41	16–80	3 years
F2	743			1 ,,
F3	1,722			1 ,,
F4	893			1 ,,
G 1–13	969	$37\,^{11}/_{12}$	21–62	2 ,,

* * *

VIII. PSYCHOLOGICAL TESTS USED

By reading down the columns in Table XIV it may be seen which tests were given to each group of subjects, since a cross appears in the columns opposite a test when it was given to a group. By reading across it is possible to see which groups have been given each test. The same tests have not been given to all groups, for during the progress of the investigation new tests were devised and others were dropped. Some aesthetokinetic tests have, however, been given to each group so that a fair measure of their value can be obtained. The data concerning the other tests are less numerous.

TABLE XIV.—TESTS GIVEN TO THE DIFFERENT GROUPS

	GROUP				
Aesthetokinetic tests	A	B	C	D	E
Dotting	×	×	×	×	×
Co-ordination	×	×	×	×	×
Interrupted pursuit meter	×	×		×	×
Choice reaction time			×		
Pursuit meter			×		
Linguistic Intelligence tests					
Test 1 (group 33)	×				
Test 2	×				×
Other tests					
Mechanical aptitude					×
Perseveration	×				

Tests that have been used previously are not described here, but references are given to earlier reports in which full descriptions of them will be found. . . .

The relations between individual aesthetokinetic tests and accidents are not reported separately for they are regarded as a set of tests having a common factor in low saturation. It was shown in Report No. 55 (1929) that the inter-correlations of the aesthetokinetic tests are of the order of 0.26; it was shown also that it was the factor which these tests had in common, and not their specific factors, that was related to industrial accidents. It is for these reasons that they are regarded as one test, in the same way that the parts of an intelligence test are put together to form a single intelligence test. Accidents may or may not correlate with an individual test in any particular group. It is sufficient for predictive purposes to show that accidents correlate with the aesthetokinetic tests as a whole. Individually the tests are unreliable for predictive purposes, but collectively they are shown to have a relation to accidents in groups where the data are adequate.

In comparing performance in the aesthetokinetic tests with accident rate, a single combined aesthetokinetic score was used for each group. This was obtained by expressing the raw scores in each test as percentages of their own mean, and then adding these percentage scores in different tests for each subject.

IX. Relation between Certain Psychological Tests and Accidents

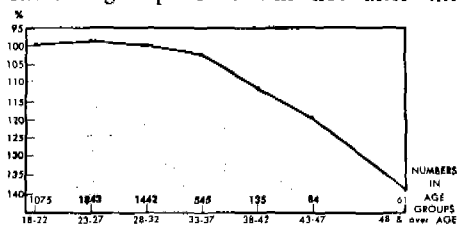
The only group in which the predictive value of the tests can be adequately judged is Group A. In this group none of the subjects had previously driven buses in London, so that they were beginners in a new occupation. All of them knew how to drive motors before they were accepted by the London Transport Board, but in spite of this they were given an intensive course in bus driving before being allowed on the London streets. They had, therefore, before being exposed to risks, reached the high standard of proficiency necessary to pass the severe driving test demanded by the Board. This method of selection ensured that each member of the group, whatever his previous experience, had reached a high standard of driving ability and so to some extent removed the error that arises when subjects are unequal in experience.

When applying psychological tests to industrial workers, we have found significant relations between the tests and accidents only in the case of beginners of equal age and experience. Whenever we have applied them to trained workers with unequal age and experience, no significant relation has been found.

Since age and experience affect accident incidence, it is easy to understand how variations in these in a group may mask any relation there may be between tests and accidents. It is also possible that experience develops in the worker mental and physical habit formations which tend to lower accident rate but which are not measured by our tests. Whatever the reason for failure, the fact remains that we find a significantly positive relation between the tests and accidents only in groups of equal age and experience. Groups C and D, composed of drivers of unequal age and experience, were tested to see if the results corresponded with those already obtained from industrial workers and they turned out to be equally indeterminate. Group B consisted of beginners and were similar to Group A in this respect.

It has been found that there is a definite relation between age and ability to perform the aesthetokinetic tests. Figure II shows this relation graphically, and it may be seen that the ability required decreases slowly after the middle twenties and more rapidly after the middle thirties. This tendency has a definite masking effect on the relation between tests and accidents in groups with a wide age range, since it has already been shown that accident rate tends to decrease with increasing age whereas ability to perform the tests also becomes less. This, however, does not affect the validity of selecting drivers practically by means of tests, for if there is a definite relationship between ability to perform the tests and accident rate, those who do badly in the tests will tend to have more accidents than those who do well, whatever their ages. The mean accident rate of a whole group may change with increasing age, but differences between individuals with high or low degrees of proneness will still persist.

A similar consideration applies to the effects of experience, although we have no evidence of any relation between driving experience and ability to perform the tests. Increasing experience will not alter the



Note The worse the test performance the bigger the percentage score. The subjects in this curve comprise all the subjects in the present report and in addition many subjects from other sources, included to make the means more reliable.

Fig. II. Mean scores in the summed aesthetokinetic tests, expressed as percentages, for subjects in 5-year age groups.

relation between individuals with different degrees of accident proneness. Further evidence on this point will be adduced later in this report.

In Group A the tests were not used in selecting the candidates, but in Group B they were taken into account and the majority of those who did badly in the tests were not accepted for employment. This has the effect of disturbing the distribution, so that in assessing the value of the tests in this group it has to be borne in mind that it is a selected group in respect of the tests that are being examined.

Group A had an exposure of five years. It was found with industrial accidents that, if the mean accident rate is low, it is only when records of a long exposure are available that a positive relation between the tests and accidents is found. Group B had only two years of exposure, so that in this respect it is not a satisfactory group to measure the value of the tests. Groups C and D had four years' exposure, but the numbers of drivers in them were small and the age and experience of the drivers in each group were very varied.

The only group, therefore, in which the experience of the members is equal, the age range narrow, the exposure lengthy and the group unselected by the tests is Group A. All the other groups fail in one or more of these respects. If the relation between the tests and accidents were really close, it might still be possible to show a positive relation between them in spite of these disturbing factors. When the relationship itself is small, interfering factors play a disproportionate part and easily mask a relationship which is itself not very close.

Aesthetokinetic Tests and Accidents: The relation between accidents and performance in the aesthetokinetic tests was examined in two ways. Table XV gives the product-moment correlation coefficients between the test scores and accidents. This method is difficult to interpret since accidents are not normally distributed, but the coefficients do at least indicate a fairly consistent though small relationship between ability to perform the tests and accident rate. In Groups A and B the coefficients are given for separate periods as well as for increasing periods of exposure, but this was not done for Groups C and D because the mean and range of accidents in separate periods were low. Values of $\frac{1}{\sqrt{(n-1)}}$, i.e. the standard error of r for zero correlation, are given for comparison, but it should be remembered that judgments of significance on the normal probability scale may not be quite accurate in this case.

TABLE XV.—PRODUCT-MOMENT CORRELATION BETWEEN THE AESTHETOKINETIC TESTS AND ACCIDENTS

	EXPOSURE	r	$\frac{1}{\sqrt{(n-1)}}$
Group A	1st year	0.125	0.089
	2nd year	0.168	0.089
	3rd year	0.062	0.089
	4th year	0.182	0.089
	5th year	0.076	0.089
	2 years	0.177	0.089
	3 years	0.161	0.089
	4 years	0.197	0.089
	5 years	0.187	0.089
Group B	1st year	−0.022	0.050
	2nd year	0.106	0.050
	2 years	0.049	0.050
Group C	4 years	−0.083	0.108
Group D	4 years	0.083	0.141

The second method of examining the relationship was to divide the drivers into four interquartile groups on the basis of their test scores and to examine the mean accident rate of each of these groups. The significance between the mean accident rates of the best and worst interquartile groups was examined. The results of this method are shown in Table XVI.

It may be seen in Table XVI that in most cases the mean accident rate of the worst interquartile group is higher than that of the best interquartile group, and that in the case of Group A, with longer periods of exposure, it is significantly higher. The general conclusion may be drawn that in Group A there is a positive relation between the aesthetokinetic tests and accidents which is significant for the longer periods of exposure. In Groups B, C and D there are no significant differences, though Group D and the two-year period of exposure in Group B show the same tendency as Group A.

TABLE XVI.—MEAN ACCIDENT RATE OF THE INTERQUARTILE GROUPS IN THE AESTHETOKINETIC TESTS

GROUP A

	TOP 25%		2ND 25%		3RD 25%		BOTTOM 25%	
	Mean	S.D.	*Mean*	S.D.	*Mean*	S.D.	*Mean*	S.D.
1 yr.	1.5000	1.803	2.1176	1.937	1.6364	1.367	2.1724	1.703
2 yr.	2.8125	2.391	3.6176	2.776	3.3636	2.199	4.1724	2.995
3 yr.	4.1250	3.059	5.2941	3.222	5.2121	3.072	6.1034	4.397
4 yr.	5.5000	3.579	6.5588	3.449	6.5758	3.456	8.1724	5.318
5 yr.	6.8750	4.540	8.2059	4.078	8.0000	3.908	9.9655	6.189
Nos.	32		34		33		29	

Significance of the difference between the means of the top and bottom interquartile groups.

1 year $t = 1.47$
2 years $t = 1.94$
3 years $t = 2.02$
4 years $t = 2.28$
5 years $t = 2.20$

(*Note.*—It was not possible to test all the drivers in this group. The total number of drivers who did the aesthetokinetic tests was 128.)

GROUP B

	TOP 25%		2ND 25%		3RD 25%		BOTTOM 25%	
	Mean	S.D.	*Mean*	S.D.	*Mean*	S.D.	*Mean*	S.D.
1 yr.	2.1111	1.699	2.3030	1.560	2.2577	1.749	2.0097	1.485
2 yr.	3.6869	2.268	3.9697	2.484	2.8454	2.235	4.0583	2.413
Nos.	99		99		97		103	

The differences between these means are not significant.

GROUP C

	TOP 25%		2ND 25%		3RD 25%		BOTTOM 25%	
	Mean	S.D.	*Mean*	S.D.	*Mean*	S.D.	*Mean*	S.D.
4 yr.	3.5909	2.552	4.1818	2.741	2.7619	1.998	2.9048	1.540
Nos.	22		22		21		21	

The differences between these means are not significant.

GROUP D

The number of drivers who had taken the aesthetokinetic tests in this group was so small that they were divided into only three groups instead of four.

	TOP 3RD		2ND 3RD		BOTTOM 3RD	
	Mean	S.D.	*Mean*	S.D.	*Mean*	S.D.
4 yr.	4.9091	2.695	5.9130	3.635	5.8636	2.817
Nos.	15		19		17	

The differences between these means are not significant.

Intelligence Tests and Accidents: Two intelligence tests were used. A group intelligence test, published by the National Institute of Industrial Psychology and known as Test No. 33, was designed by Burt primarily for the use of boys from 14 to 17 who had left school. We have used it on a large number of subjects and have found it a most useful measure with young people. To provide a suitable intelligence test for adults who have left school at 14 years of age is difficult. The men feel a strange nervousness when faced with a pencil and a set of printed questions, and the general trend of their remarks is to the effect that they have left school a long time and cannot be expected to do tests of this kind. Evidence of the unsuitability of this test for such subjects is provided by the fact that the drivers in Group A had an average score in the test of 64, whilst a group of apprentices of mean age 16 scored an average mark of 120. This cannot, of course, be taken to indicate that the drivers were really greatly inferior in intelligence to the apprentices, but rather that the test was not suitable for both groups.

We devised a simpler form of group intelligence test in the hope that it might be less alarming to the subjects, but we do not feel

TABLE XVII.—MEAN ACCIDENT RATES OF THE INTERQUARTILE GROUPS IN THE INTELLIGENCE TESTS IN GROUP A

	TOP 25%		2ND 25%		3RD 25%		BOTTOM 25%	
	Mean	S.D.	*Mean*	S.D.	*Mean*	S.D.	*Mean*	S.D.
Test 1	8.2000	4.479	7.7619	3.772	7.7619	5.446	8.3333	4.612
Test 2	7.8810	4.260	7.8780	3.971	8.4048	4.675	7.8780	5.442

None of the differences between these means is significant.

that we have succeeded. The men still appeared to be unduly nervous and did not respond with the keen interest that all subjects show in the aesthetokinetic tests.

Table XVII shows the relation between these intelligence tests and accidents in Group A.

It would be unwise to draw the conclusion from these data that differences in intelligence are not related to differences in accident rate. We are not satisfied that the measures of intelligence were suitable for the adult population on which they were used, and until more satisfactory measures are forthcoming it would be wiser to conclude that at present the relation between differences in intelligence and accident rate has not been adequately explored.

Perseveration Test and Accidents: The perseveration test used was also not a very suitable one, for it, too, was a paper test and produced the same nervousness as the intelligence tests.

Those who on this test appear to be perseverators have a slightly higher accident rate than the non-perseverators, but the difference is not significant. We do not know of any other perseveration tests suitable for the conditions under which the tests were given, but one may be forthcoming which will yield a more satisfactory measure of perseveration, which is a factor well worth measuring in relation to accidents. One would expect perseverators to have a higher accident rate than non-perseverators, since the former lack the ability to break down established habits quickly, and the demands of a continuously changing environment, as in driving in traffic, might find them incapable of making sufficiently rapid adjustments and reactions.

Table XVIII shows the difference in accident rate between the perseverators and non-perseverators in Group A.

* * *

XIII. SUMMARY AND CONCLUSIONS

(1) The accident records of several groups of motor drivers have been examined to see if the distributions of accidents are consistent with the hypothesis that some people are more liable to accidents than others under conditions of equal exposure. It is clear from the data that accident proneness among motor drivers is an important factor in the causation of accidents.

(2) Certain psychological tests were given to some of the groups of subjects, with a view to measuring some of the functions involved in accident proneness. In those groups where the accident records were suitable it was shown that those who failed in the tests had a higher average accident rate than those who passed.

(3) It was found that those who had an undue number of accidents in their initial period of exposure tended to have a higher subsequent accident rate than others.

(4) If either of these methods of detecting accident proneness is employed to eliminate certain drivers from the population at risk, future accident rate is reduced. The best results are obtained by using both methods in conjunction.

(5) Accident proneness was shown to manifest itself in all kinds of accidents and throughout all conditions of exposure.

TABLE XVIII.—MEAN ACCIDENT RATE OF PERSEVERATORS AND NON-PERSEVERATORS

Group A	*Mean accident rate*	S.D.
Non-perseverators	7.8205	4.801
Perseverators	8.2899	4.650
Difference	0.4694	
S.e. of difference	0.780	

(6) It was shown that experience, although it lessens accident rate, does not affect differences between those who are specially prone and others. The former always have a higher accident rate than the latter, in spite of the increasing experience of both.

Unfortunately, Farmer and Chambers go far beyond their data in concluding that "Accident proneness was shown to manifest itself in all kinds of accidents and throughout all conditions of exposure." The report does not adequately document whether the *quality* and *quantity* of the exposures of the various groups were the same, and the comparisons of accident rates by year, month, and hour do not answer this question. In addition, the work that served as the basis for the conclusion that accidents are not randomly distributed was further compromised by the unwarranted conclusion that this is due to stable psychological characteristics. The tests used were of doubtful validity and only one of them, the aesthetokinetic, which can hardly be called a personality measure, proved significant. Nonetheless, only their conclusions are considered and quoted by many concerned with accident research. This has favored the development of a folklore of accident proneness, which does not correspond closely to the evidence on which it is said to be based. As more and more personality tests were used in subsequent research, the contradictory and confusing findings that resulted brought the accident-proneness concept advanced by Farmer and Chambers into disrepute among informed research workers, but not among the public. We turn now to some of the more recent papers in this field.

THE PHENOMENON OF ACCIDENT PRONENESS

—A. G. Arbous, J. E. Kerrich

One of the most decisive critiques of the accident-proneness concept appeared in 1951 in a long article by Arbous and Kerrich, of the South African Council for Scientific and Industrial Research. Divided into two parts, one a clinical evaluation of the accident-proneness concept and the other a mathematical analysis of accident proneness, this article had a profound effect on the field.[6] Although there are some who believe this analysis should have sounded the death knell for the accident-proneness approach, a more reasoned evaluation would consider it a warning against the indiscriminate use of this concept to explain all cases of repeated accidents. For one cannot claim, on the basis of current evidence, that no cases of accident proneness exist. At the present stage of knowledge, we might best conclude that accident proneness as an explanation for any major proportion of repeated accidents is unwarranted but that, as a clinical phenomenon limited to some individuals, it may have some validity.

This selection, a condensation of the original lengthy analysis, places relatively heavy emphasis on the clinical evaluation of the accident-proneness concept. The importance of this analysis lies not only in its challenge to the accident-proneness concept on statistical grounds but also in its proposal for a more psychological and clinical approach to accidents. It presents, moreover, valuable critiques of several major studies.

IN THE PAST accidents were attributed to bad luck or the visitations of some unpropitious deity. Today they are regarded as a social problem. Several factors have combined to reorientate our thinking in this regard, and it is appropriate that the study of accidents should be made against the background of significant changes which have taken place in our mental attitudes during the past quarter-century. . . .

The wider acceptance of psychology as a science, and the consequent development of psychosomatic medicine have led to a deeper appreciation of the possible causes of accidents. These occurrences are no longer regarded as inescapable by-products of our mechanical age which have to be accepted in a spirit of fatalism. As man has become more willing to apply scientific techniques to the study of his own behavior, his attitude to this phenomenon has undergone considerable change. Accidents are no longer regarded as entirely fortuitous events and the inevitable price to be paid for technological advancement. Events which were previously considered to be chance-determined are now regarded as preventable, and causes which were hitherto regarded as beyond the control of the individual are now seen in many cases as intimately related to his psycho-physiological make-up. It is not a question of the blame being shifted from the environment to the individual, but rather an appreciation that what really matters is the degree of adjustment which exists between the two. Our appreciation of the wide range of individual differences which exist in man has led to the natural conclusion that considerable improvement can be effected in human adjustment by a more careful consideration of those aspects of the environment which are man-made, and also the varying of skill, mental ability, physical constitution, temperamental and personality qualities with which individuals are equipped. As a result accidents are today more often regarded as problems of human adjustment, or as manifestations of maladjustment.

THE PHENOMENON OF "ACCIDENT-PRONENESS"

People first stumbled on this idea when it was observed that, in most work-groups studied, a minority were responsible for the majority of accidents. This spectacular observation led the unwary in the past to formulate the concept of accident-proneness as a means of explanation.

It is a difficult matter to define what is meant by this term and evolve a sensible measure of whatever it indicates. Apparently it was meant to define some personal trait as opposed to some characteristic of the environment, which predisposed some to have more accidents than others in work conditions where the risk of hazard was equal to all. The term would appear to imply moreover that it is possible either (a) to differentiate clearly between two classes of people—those who are accident-prone, and those who are not; or (b) at least to be able to rank the group in terms of the severity of their proneness.

Even today, after the trenchant comments of writers like Mintz and Blum, the fallacy of this line of argument, based on the distribution of accidents in a single period of observation, does not appear to have penetrated the mind of the layman, or even of many specialists working in the field of accident prevention. It is appropriate therefore, in our study of this phenomenon, that we should drive this point home by considering from an actual example the extent to which the accident-proneness concept enables one to differentiate between persons with the hope of producing beneficial results.

The implied advantage of this theory is that after having spotted who the accident-prone cases are in a group, their removal from the group should result in a decrease in the relative frequency of accidents sustained by the remainder. The objective is laudable and obvious. If it cannot be achieved there is little point in our clinging to the concept of proneness.

The fallacy of this line of reasoning is strik-

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ingly revealed by reference to an example from Adelstein's data, covering the records of 104 shunters with three years' service. He reports the effect of removing cases with a high accident record in the first year of service as follows:

TABLE I.—THE ACCIDENT RATES FOR THE SHUNTERS WHO JOINED IN 1944 AND SHUNTED FOR THREE YEARS

	1st year	*2nd year*	*3rd year*
Mean accident rate for 104 men	.557	.355	.317
After removing 10 men with highest rate in 1st year, i.e., 94 remaining men	.393	.361	.329

In this case the annual accident rate in the second and third years actually went up a trifle after the removal of the 10 men who had had most accidents during the first year.

Clearly evidence of this type indicates that our conception of the term accident-proneness stands in need of a critical examination from first principles.

The significant history of the concept of accident-proneness goes back to 1919 when Greenwood and Woods, and Greenwood and Yule made the first thorough-going approach to the analysis of accident statistics. Their findings and conclusions were later critically examined and extended by Newbold, in her classic contributions to the subject in 1926 and 1927. Despite the fact that these studies were made about a quarter of a century ago, they still must be regarded as almost complete summaries of our existing knowledge of this phenomenon, as little real advance has been made since that time. Anyone wishing to understand the subject of proneness cannot avoid making a detailed and comprehensive study of these works, for in them he will find not only the basic assumptions on which the concept of proneness depends, but all the essential warnings as to the limitations of these assumptions which have been so often disregarded ever since. It is an unfortunate fact that since these studies were made, it has been assumed in almost all the literature that the existence of accident-proneness is an established fact, and that it is a stable phenomenon in individual make-up which makes it worth our while attempting to predict and to use in practical accident prevention measures. Thus Farmer and Chambers (who coined the term accident-proneness) state explicitly:

"Previous statistical investigations have shown that industrial workers exposed to equal risks were unequal in their liability to sustain accidents, and that this unequal liability was a relatively stable phenomenon, manifesting itself in different periods of exposure and in different kinds of accidents. . . ."

This claim would certainly not have been made by Newbold, Greenwood and Yule without certain strict provisos, and it is here suggested that most of the confusion of thought which has occurred since 1926 has resulted from an overstatement of the claims made by these authors, and a disregard of their warnings. It would seem necessary, therefore, that we should clarify our thinking on this subject by reviewing the arguments of Newbold and Greenwood and Yule, and also the results of subsequent research to see how far one is justified in accepting this concept of proneness, and what use, if any, can legitimately be made of it at present.

What is meant by the term Accident-Proneness? Farmer and Chambers state: "The fact that one of the factors connected with accident liability has been found to be a peculiarity of the individual allows us to differentiate between 'accident-proneness' and 'accident liability.' 'Accident-proneness' is a narrower term than 'accident-liability' and means a personal idiosyncrasy predisposing the individual who possesses it in a marked degree to a relatively high accident rate. 'Accident liability' includes all the factors determining accident rate: 'accident-proneness' refers only to those that are personal." From the above it is obvious that environmental factors plus the personal factor of accident-proneness in the individual determine the accident liability of individuals in any given situation. It is, however, concerning the latter that confusion has arisen. This term is widely used in current literature and yet it is scarcely ever well defined. This is apparent even in the technical language of some of the authorities. Thus Vernon in 1936:

"The accident-proneness of various individuals is not a fixed quality but is liable to be affected by any and every change in their bodily condition. This condition is influenced by external changes of environment as well as by internal changes of physical and mental health."

This statement clearly implies that accident-proneness is a variable attribute, whereas in 1939 the same author states:

"Accident liability is influenced by many other personal qualities besides inherent accident-proneness. It depends on general health . . . age and experience, fatigue, etc. . . ."

This second statement suggests that "inherent accident-proneness" is a stable invariable attribute of the individual (in much the same way as we regard his general mental ability, manual dexterity, etc.) and that accident liability depends on: (a) inherent accident-proneness; (b) variations in personal health, age, experience, fatigue, etc.; (c) the risks inherent in the environmental situation.

Whether or not Vernon changed his mind between 1936 and 1939 is beside the point for he certainly gave no indication that this was so in the later work, and the reader is still left in a state of indecision. The point has been raised here not with the intention of splitting hairs, but by way of illustrating the lack of precision in our thinking on this subject. It is of vital importance, moreover, whether accident-proneness is a stable or variable attribute, for surely there would be little point in attempting to devise means of measuring or assessing an unstable phenomenon. The general 'belief' today is that accident-proneness is a fairly stable attribute. However, of equal importance is the question as to whether it is a general or specific factor. Thus it is conceivable that A may be more prone than B in situation X, but B more prone than A in situation Y. On the other hand, it may well be that no matter what the situation is A will always be more prone than B, although the liabilities of both will have changed by the same amount owing to the different risks in the situation itself. This latter view is one which is quite generally held, and the accident-prone individual is regarded as one who has many accidents at home, at work, on the public highways, and is in fact a sort of "calamity Joe" who is always "coming unstuck." There is, however, no proof for either of these two hypotheses and some pertinent comments have been made in this regard by Brown and Ghiselli. Again the matter is an important one for prediction and accident prevention policies.

It is clear from the above that the term accident-proneness should be clearly defined before we attempt to make any practical use of it. A clear conception of its meaning can only be obtained by a close scrutiny of our existing knowledge and the methods of analysis which have given rise to it. These are, fortunately or otherwise, of a mathematical and statistical nature. They cannot, however, be avoided for they involve basic assumptions which we cannot afford to ignore. Unless the student is prepared to study these carefully and comprehend their full implications, he would be well advised not to make any use of the term accident-proneness at all until a new meaning is given to the word on the basis of research findings resulting from a new approach. There is regrettably a tendency among many psychologists today to forget, conveniently or unconsciously, about the assumptions underlying all mathematical and statistical "proofs" and the fact that it is never possible in any science to prove a hypothesis. The result is that often claims are overstated, tenuous relationships are magnified to causal relationships, and possibilities become certainties as one turns over the pages of the literature. We can only avoid this slipshod method of thinking by sticking closely to the evidence before us. . . .

The Prediction of "Accident-Proneness"

Considerable advantages would be gained if techniques could be discovered which would predict the accident-proneness of individuals (if such a phenomenon exists) in a given situation, before they had actually

entered that situation and incurred accidents. These are clearly stated by Farmer and Chambers in their successive attempts to do so. The authors are also careful to point out that:

"Care must be taken not to make accident incidence *per se* a measure of accident-proneness, for this is to adopt the position of those who say that accidents are due to carelessness and when asked to define carelessness, do so in such a way as to leave little doubt that by carelessness they mean having an undue number of accidents. 'Accident-proneness' implies the possession of those qualities which have been found from independent research to lead to an undue number of accidents. If the term is used in this way a person can be said to be accident-prone without any knowledge of the number of accidents he has sustained, for this statement will merely mean that he is more likely than others in equal conditions of exposure to sustain accidents. Such a knowledge would make it possible to warn certain people against entering dangerous occupations, so that although they were accident-prone in a relatively high degree, they might go through life with very few accidents."

Be this as it may, the fact remains that the discovery of these "qualities" can only be achieved by measuring the validity with which certain tests can predict some criterion of accident-proneness in a given group. This criterion can only be the number of accidents sustained by the respective individuals in that group. Moreover, whether or not "accident-proneness" really does exist, we should be happy if we could predict the *number of accidents* a person is likely to have. Hence, a good fit with some theoretical bivariate distribution is of considerable importance quite apart from what the parameters happen to signify. And this is the obvious line of approach which the investigators take. A further point must be made in this connection. Prediction only becomes feasible when the criterion of the attribute to be predicted is itself reliable and stable. If an individual's accident record in the same set of circumstances is an unstable reflection of his "inherent accident-proneness," then prediction of proneness by this means must be a shaky affair. The correlations between the incidence of accident shown earlier in this study indicate quite clearly that there is very little consistency in the records of individuals from period to period. It is not surprising therefore, that all attempts to predict accident-proneness using accident records as a criterion or measure of this have so far failed rather lamentably. The investigators in 1933 appear to have been fully aware of these difficulties for they state: "Unless individual susceptibility to accidents is a stable quality manifesting itself during all periods of exposure, we cannot expect a very definite relation between psychological tests and accident rate," and later in the same report, "Attention has been called to its smallness (i.e., correlation) since it shows that accident susceptibility is not a very stable factor within these groups; hence it cannot be expected that performance in any test purporting to measure susceptibility will have a very close relation with recorded accidents."

What is surprising, therefore, is that the investigators should have persisted in the face of these insurmountable difficulties before establishing a more stable criterion of proneness.

Having been unsuccessful in their first and second attempts, the investigators proceed to a third and a fourth and the reader is amazed to find the latter report opening with what can only be regarded as a statement of creed, in view of the absence of any intervening research findings, which could alter the position as stated by them above. This is reflected here for comparison with the quotation already given: "Previous statistical investigations have shown that industrial workers exposed to equal risks were unequal in their liability to sustain accidents, and that this unequal liability was a relatively stable phenomenon, manifesting itself in different periods of exposure and in different kinds of accidents."

Furthermore, the stability of their own criterion in this particular case (as reflected by correlations between accidents in suc-

cessive periods) was only of the order of .176 to .328.

It is not surprising, therefore, that despite the one or two refinements introduced in the constitution of groups tested, these latest attempts should have yielded only inconclusive results. Surely if the efficiency with which the criterion can predict itself is only of the order of .3, then it is a fond hope to expect that any test, which can only measure part of the criterion, will have a predicting efficiency as great as or greater than .3.

Had the above research findings been more positive, they would have warranted fairly detailed consideration in this study. As it is, a summary of the main conclusions will suffice. The student who is interested in making further attempts on this problem is, however, strongly advised to study the original works if only to acquaint himself with the type of difficulty to be encountered, and the pitfalls to avoid. These will be largely concerned with: (a) the selection of appropriate experimental groups, and the control of such influences as age, experience and environmental factors; (b) the definition of events which are to be regarded as accidents, and the completeness and accuracy of these data; (c) the stability or consistency of accident records in successive periods as a measure or criterion of personal accident-proneness; (d) the adequacy of existing instruments of statistical analysis, and the precautions which must be taken against the use of techniques which are suspect, to say the least, when applied to frequency distributions associated with accident data. The techniques usually applied in psychological research are, for the most part, dependent upon the normal distributions and correlation surfaces. Accidents on the other hand are a discrete variable and yield J-shaped or negative binominal distributions. This fact alone alters the whole meaning and predicting efficiency of the ordinary product-moment correlation co-efficient. Above all it is essential to avoid the folly of applying statistical procedures, knowing at the same time that they cannot be justified on mathematical grounds. Self-deceit of this type has never produced any results worth having. . . .

Over and above these difficulties hangs a "sword of Damocles" in the form of the inconsistency of the criterion to be predicted. Owing to this factor it is conceivable that the validity of indicators already established may be seriously upset. It is feared that the investigator will always come up against this statistical stumbling block. If the incidence of accidents in successive exposure periods is as unstable as previous research findings have shown it to be, then surely, one can hope for little efficiency in one's predicting techniques. There is of course, the final hope that if more attention is given to the definition of accidents to be included in the study this deficiency may be overcome. The unreliability of the criterion may in some measure be due to the fact that accident data are not uniform, and that by merely including for study all accidents (from existing records) irrespective of causes or the manner in which they occurred, one is in effect collecting a 'hotch-potch' of events which are by no means homogeneous or representative of the phenomenon of proneness. The result may be similar to that of mixing measures of height and weight or scores from test A and test B in the same distribution.

This point might well be elaborated for the consideration of future research workers. It is felt that in most previous research scant attention has been paid to the definition of what constitutes an accident. It is appropriate that the following questions should be asked and answered: (1) What are the phenomena that are being studied? What is our variable? What constitutes our total statistical population of events? (2) If it is not possible to record the total population of events in any given set of circumstances, what sample can we hope to study? (3) How is this sample selected, and is it representative of the whole?

An accident might justifiably be defined in the following manner: "In a chain of events, each of which is planned or controlled, there occurs an unplanned event, which, being the result of some non-adjustive act on the part of the individual (variously caused), may or may not result in injury. This is an accident."

There are certain aspects of this definition

which need emphasizing. Firstly, it is the occurrence of the unplanned or unpredicted event which constitutes the accident. Secondly, this event is due to some non-adjustive act on the part of the individual concerned. Thirdly, the resulting injury is a consequence of this unplanned event, and does not itself constitute the accident—it follows afterwards. From this it follows that our statistical population of events is the sum total of all unplanned incidents in the given environmental circumstances and in the given population of individuals. By definition also, these will exclude all events which can definitely be attributed to the influence of mechanical or impersonal causes—e.g., the case of an omnibus driver being stung by a hornet, inherent defects in the machine, etc. This naturally implies a strict investigation of all accidents in order to establish the factor of personal causation. This will also serve the purpose of debiting the correct individual for the responsibility of the accident. Thus if A drops a brick and it falls on B's head, the former has the "unplanned event," and the latter the injury; who has the accident? The answer surely is A and not B who is usually debited with this in the register.

By definition all the following must be regarded as constituting our population of accidents: (1) all errors or slips or "near accidents" which result in no injury; (2) all unplanned events resulting in minor injury; (3) all unplanned events resulting in major or lost time injuries which incapacitate; (4) all unplanned events resulting in death.

We might consider to what extent these data can be made available.

1. *Errors, Slips and Near Accidents.* Here we can be almost sure that data in respect of these would be incomplete, even with the most rigorous supervision. It might be profitable, however, to set up experimentally controlled conditions in a laboratory equating the environmental circumstances for all subjects and undertake the study of errors in some series of test situations. This might well throw some light on the proneness of individuals to this type of "accident," which could perhaps be related to accidents in the industrial situation.

2. *Accidents Producing Minor Injuries.* Only under highly controlled conditions could one be sure of amassing data which were complete and accurate, and which did not merely reflect a tendency on the part of some to report these incidents.

3. *Accidents Producing Major Injuries.* Here one could be reasonably sure of collecting all the data. The difficulty is, of course, that incapacity usually means a subsequent period of non-exposure which may be of considerable length and may even result in the removal of the individual from the work situation.

4. *Accidents Resulting in Death.* Here one is virtually certain of the data, but these occurrences are inevitably followed by subsequent non-exposure.

This self-elimination of many of our cases (and unfortunately they are the very ones whom one is interested in studying) has a serious effect upon subsequent statistical analysis.

Thus under normal circumstances (i.e., excluding those subject to the highest degree of control and supervision) one can only be reasonably sure of collecting and including *complete* data on major accidents. This means that we get a selected sample of our total population of "unplanned events" (or accidents) for study, *and this sample is selected purely in terms of subsequent injury.* Now if the resulting injury is determined *by chance*, this would mean that we should get a random or representative sample of our total population of events. This would be extremely fortunate, for any conclusions arrived at on the basis of this sample would then be applicable to the total population of events. If on the other hand the resulting injury were not chance determined but were in some way a function of the manner in which the unplanned event originally occurred, then we should be left with a selected sample, and statistical results could no longer be applied to the parent population from which these events came. It might be justifiable to argue that in any case one is only interested in studying major accidents and not the minor which have trivial consequences. This may well be so, but it must then be

conceded that one is no longer studying accidents but merely the incidence of injury resulting from accidents, which may have nothing to do with personal liability.

Under the circumstances where one is studying accidents causing major injury only, it would appear that there are two "*liabilities*" to be considered: (a) the liability of the individual to have an unplanned event or accident in a given environment, (b) the liability of this event to result in subsequent injury in a given environment—resulting in its being recorded.

It is conceivable, therefore, that if injury were not chance determined the following results may be obtained where—

e—represents unplanned events without injury,

(e)—represents unplanned events with major injury, and the suffix indicates the type of accident.

In the case of two individuals the results might well be:

Individual A—e_1, e_1, e_3, (e_7), e_9, e_{12}, e_3 = 1 reported major accident

Individual B—e_1, (e_7), (e_7), (e_4) = 3 reported major accidents

In the records B would obviously be considered more accident-prone than A, but this would not be a reflection of his proneness to unplanned events (slips or near accidents), since B has only four, whereas A has eight. It would rather be a reflection of the liability of such events as he had to result in injury. This may well be determined by factors beyond his control, and the study of the (e)'s would give little indication of the individual's susceptibility to (e)'s.

It is appreciated that the development of this theme of the "double liabilities" tends to lead to a state of confusion where one feels that the problem slips one's mental grasp. This is not because the argument itself is confusing, but rather because we have not yet devised techniques of analysis which will enable us to disentangle the skeins of a confused and intricate pattern of events. Furthermore, our attempts to oversimplify the accident-causing situation by seeking to subdivide it into "personal causes" and "environmental causes" tends to lead us nowhere. Greenwood and Woods in their original report recognized that "individual susceptibility sheltered a motley host of motives and factors which will be very difficult indeed to separate and measure." Surely the essence of accident causation is the rather intricate inter-relationship which exists between the individual and the environment and the influence of one cannot be appreciated without considering its inter-action with the other, and to attempt to separate the two is about as profitable as attempting to unravel the respective influences in the heredity *versus* environment controversy. Full comprehension of these inter-relationships and their statement in universal "laws" will possibly only be achieved when we have evolved statistical techniques which will facilitate three- and perhaps four-dimensional thinking in these matters. Existing methods of analysis tend to make the problem too simple—too dependent on the direct cause-and-effect relationship.

It is conceivable that with our present instruments of analysis we may yet succeed in pinning down the personal factor in accident-causation (or accident-proneness) in terms of some strict definition—but this may involve so many restrictions in the mathematical sense that the concept will bear little relation to the real factors in the everyday industrial situation. The above comments do not constitute a denial of the usefulness of statistical procedures in investigations of this type, nor is it suggested that the research worker can ever dispense with them altogether. The conclusions indicate rather the limitations of these techniques, and emphasize the fact that statistics can never do your thinking for you.

The above considerations may well lead one into a state of despondency and frustrated resignation were it not for the fact that a different approach to the problem seems possible. This approach may not enable us to analyze accident liability in terms of universal principles, laws of distribution, etc., with reference to human behavior in general, but it may well enable us to reduce the inci-

dence of accidents in our community by enhancing our knowledge of the mechanisms at work in causing individuals to have accidents. And surely this is the ultimate objective of all this work. This approach has been clearly explained by Viteles in his reference to the accident reduction programs of the Cleveland Railways Company. Viteles' introductory comments to these studies are worth considering:

"The psychological study of accidents in the manufacturing industry has been largely confined to a statistical study of factors influencing accident susceptibility. Such statistical studies are of questionable significance in arriving at a knowledge of the causes of accidents. . . . However, they suffer from serious limitations as practical aids in the reduction of accidents.

"In the first place the statistical approach is oriented from the viewpoint of discovering relations existing in a group of individuals, and not from the point of view of the adjustment of the single individual who has become involved in, or is susceptible to accidents. . . . The function of the statistical approach and of statistical investigations in preventing accidents attributable to the human factor may be described as that of investigatory *group* tendencies. In contrast with this is the *clinical approach*—the functions of which are to determine the relationship existing among a number of factors which have played or may play a part in the case of the individual who becomes involved in accidents and to develop a program for the prevention of additional accidents on his part.

"Another limitation of the statistical viewpoint in accident prevention is its emphasis upon isolated aspects of individual personality, in contrast with the concern, in the clinical approach, for the total personality of the accident-prone individual. . . . It is undoubtedly true that a detailed examination of each stone tells much about the *structure* of a mosaic, but the contribution of each to the value of the whole flows from the *integration* of the various parts, and can only be fully determined through an examination of the whole, and of the inter-relationships among the parts in the whole.

"The aim of the clinical approach is to examine the whole individual, and from an examination of the whole to arrive at a knowledge of the significance of the various aspects of his personality—the relative importance of each sector of his personality in a given situation. The application of the clinical approach in the analysis of accident causes involves a complete study of the individual involved in accidents—it makes the individual the point of departure, and provides for a thorough examination of every factor—physical, mental, social, and economic, and of those extraneous to the individual—which may have played a part in the accident in which he has been involved.

"The diagnosis of accident-proneness is being followed by special treatment, and treatment based on an exact knowledge of the factors which are responsible for the accident record—in the care of the particular individual. Treatment takes the form, not of mass education, or the more drastic measure of termination, but most frequently that of systematic instruction designed to efface faulty habits . . . . medical treatment, discipline, encouragement and supervisory follow-up . . . . It recognizes that there are many different causes of accidents and that they may combine in different patterns in different individuals.

"The knowledge of the factors which play a part in the case of a single individual is obtained by an experimental study of the individual. This includes psychological examination, close observation of operation details, a review of his relationship with supervising officers and fellow-workers, and possibly a detailed study of the home circumstances.

"The case study of each accident-prone motorman in the Cleveland Railway Compay involved: (1) A careful examination under normal operating conditions of: (a) general operation, (b) motoring habits, (c) mental factors, (d) physical factors. (2) Analysis of previous and current years

accident record. (3) Personal interview. (4) Decision as to primary causes of accident-proneness. (5) Preparation of report of case recommending treatment based upon findings. (6) Treatment and follow-up."

The most significant finding of the Cleveland study is that in no two cases were the causes of accident-proneness exactly similar. In most instances, several causes existed, although in each case, one of these was found to be of primary importance. The percentage distribution of primary causes of accident-proneness among the 50 men is given in Table II.

TABLE II

	%
Faulty attitude	14
Failure to recognize potential hazard	12
Faulty judgment of speed and distance	12
Impulsiveness	10
Irresponsibility	8
Failure to keep attention constant	8
Nervousness and fear	6
Defective vision	4
Organic disease	4
Slow reaction	4
High blood pressure	2
Senility	2
Worry and depression	2
Fatigability	2
Improper distribution of attention	2
Inexperience	2
Miscellaneous	6

As a result of this application of the clinical method in the study and treatment of motor drivers, the combined rate of accidents on the part of the motormen involved in the study dropped from 1.31 per 1,000 miles in 1928 to .75 in 1929—equivalent to a reduction of 42.7%.

Viteles quotes the experiences of the accident clinics run on similar lines at the Milwaukee Railways & Light Company (under the direction of Dr. Bingham) and illustrates the value of these techniques by stating that: "As a result . . . . the actual net savings in cost of injuries and damages in 1929 as compared with 1928 amounted to $300,670. Collision accidents on bus lines and street railways have been reduced more than 35% since the work was started in 1927. . . . The figures for 1931, as compared with those for 1926, show a 58% reduction in collision of surface cars with trolleys; 54.4% with pedestrians; 71.3% with other surface cars; 36.8% in boarding and alighting accidents; and 23.6% in all other accidents. . . . Associated with these economic returns are enormous social benefits in reducing the suffering and the general social maladjustment associated with personal injury resulting from accidents."

Spectacular though these results are, their achievement should not pass without certain comment:

1. The application of these procedures can be an expensive business where one spends a considerable time on individual cases. In the case of railway accidents where the consequences are very severe on account of the large insurance and damages claims, etc., the proposition becomes an economic one. It is doubtful, however, whether many industries could be persuaded to adopt similar measures where, owing to the lesser consequences of accidents, the economic gains would not necessarily show a profit in the financial statement, even though the social and indirect gains might be equally as great.

2. These results do not necessarily constitute a validation of the clinical procedures used nor of the diagnoses made in individual cases. This can only be achieved by their application to (a) an experimental, and (b) a control group, as was done in the Hawthorne Experiment of the Western Electric Company. The point is, of course, that the results may be just as "screwy" as they were found to be in this classic experiment, namely, the accident rates in the control group (receiving no treatment) may also go down, not because of any measures being adopted in their own case, but principally because they were being applied in the case of another group. This might indicate that individuals were responding, not so much to the "shrewdness" of diagnosis, as to the new interest being taken in them by management—to the new psychological atmosphere prevailing in the works. It is conceivable that the diagnoses may not have been directly responsible for the results. These may have been due primarily to management's interest in the situation. Employees were taken into management's confidence. Their problems were discussed with them in a sympathetic manner which enabled them to understand them

better; this probably created a new attitude of mind on the part of the workers to the problem of accidents, and encouraged them to think of safety in new terms, and to regard their work habits in a new light. They were thus able to see the significance of causes and relationships which had probably never occurred to them before, and to heed these in the everyday work situation. It is possible that this new mental approach pervaded the whole work group as the result of clinical studies, and may well have been the more general and underlying factor responsible for the spectacular results achieved. The natural rejoinder to these comments is: "Does it matter, as long as the results are forthcoming, and the whole business is a paying proposition?" This point is readily conceded, but the truth of the matter is of fundamental interest to the investigator. It may well be that the accident clinicians on these railways were not really gaining so much knowledge concerning the direct relationship between personal factors and accidents, as learning what Roethlisberger has called "new social skills." If this is so, then the development of these is of the utmost importance. It may be possible, therefore, in the future to define these techniques along new lines, and make them more of an economic proposition to the average industrial plant.

3. The third point to be emphasized here is the fact that the term "accident-proneness" is now no longer used in the original sense. It is now defined on the basis of a *clinical* and not a *statistical* diagnosis, and, as such, is largely a term of convenience, rather than of precise mathematical definition. This loss of precision is perhaps more than compensated for by the advantages of a new approach "which places special emphasis on the individual . . . and recognizes the great variety of individual differences. In dealing with each motor-man, truck driver, or automobilist, he is recognized not as one of the mass, but as a distinct personality."

The points made by Arbous and Kerrich are fundamental not only to an evaluation of accident proneness but also to an analysis of more general problems in accident research. Of particular interest is the statement:

> . . . our attempts to oversimplify the accident-causing situation by seeking to subdivide it into "personal causes" and "environmental causes" tends to lead us nowhere. . . . Surely the essence of accident causation is the rather intricate interrelationship which exists between the individual and the environment and the influence of one cannot be appreciated without considering its interaction with the other.

PERSONALITY CHARACTERISTICS OF ACCIDENT REPEATING CHILDREN

—*Vita Krall, Ph.D.*

Although there is good reason for skepticism about accident proneness on a statistical basis, the concept may nevertheless have utility for the clinical differentiation of an extreme type of individual who, for psychological reasons, may seek self-harm through incurring an accident. Arbous previously made this point about the possibly valid limitation of the concept to clinical cases. In the present article, Krall offers evidence concerning the clinical aspects of accident proneness among children.

The major psychoanalytic hypotheses to be tested were that the accident-prone child (1) has more frustration-induced aggressive drives than the accident-free child and (2) has more guilt about and fear of punishment for the overt and direct expression of frustration-induced aggressive drive. Furthermore, study of the child's home

atmosphere might be expected to shed light on a third hypothesis, namely: "This atmosphere of dominance and command, and limited affectionate contacts is reflected in the accident-prone child's perception of reality."

The method used was a standardized doll-play interview involving the scoring of aggression anxiety. The subjects were 32 five- to eight-year-old children with a record of three or more accidents in a four-year period prior to the study matched with 32 accident-free cases. Scoring was done by experienced clinicians. We are not told whether this was a "blind" test, with scorers unaware of the accident record of the child.

The results of this study supported the hypothesis that the accident-repeating group would show more aggressive behavior than the accident-free group. Findings on the aggression-anxiety hypothesis were inconclusive, being, in general, inconsistent. In regard to family background, there was some evidence that the home environments of the accident group were more disorganized than those of the accident-free group. (Similar findings have been reported from the controlled study of childhood pedestrian accidents. See Chap. 8.) Thus, on the basis of this type of clinical evaluation, there is reason to believe that the kind of child who has repeated accidents has, indeed, a personality structure significantly different from that of the accident-free child.

THE ACCIDENT PRONENESS hypothesis simply stated is that there is a tendency for certain individuals to have repeated accidents. This was postulated to account for the early discovery that sample populations of adult workers included individuals who had more accidents than could be accounted for by chance alone. More recent findings appear to minimize the importance of the statistical evidence for the accident proneness hypothesis.

If we are willing to accept Cobb's assignment of the variance in accident distributions to both chance and differential liability factors, however, it follows that certain individuals might be included among the high accident group by chance alone, while others are included because of differential liability. There are indications in the clinical literature to suggest that there are individuals who by virtue of special personal characteristics continue to have repeated accidents. It is this writer's suggestion that these are the people whom it is necessary to isolate for adequate validation of the accident proneness hypothesis as a clinical concept. King has pointed out:

> The test of the hypothesis lies in the success or failure to identify causal physiological or psychological characteristics, or their combination, present in individuals showing a high frequency of accidents, and absent or present to a lesser degree in "accident free" individuals with a comparable background of experience.

The present study was an attempt to validate the accident proneness hypothesis as a clinical concept. It was felt that an investigation of personality characteristics which predispose to repeated accidents in children might throw light on the reasons for childhood accidents as well as on the concept of accident proneness as a whole. If characteristics could be identified in childhood which are similar to those found for adults, this would add further validation to the clinical concept of accident proneness and might suggest that accident liability is continuous from childhood to maturity.

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Theoretical Formulation

The hypotheses which were tested in this experiment were derived from the theoretical, clinical, and experimental literature. The focal agreement of this literature appears to be that the accident prone individual grows up in an authoritarian, strict home environment, in which feelings of rejection and resulting hostility are fostered. The accident is said to occur as a result of inward turning of aggression.

Frustration-Induced Aggression: The source of the accident prone child's aggression is believed to be frustration of nurturance. It is assumed that all children have some drive toward nurturance, and that in the accident prone child, brought up in an authoritarian, rejecting home environment, this drive has been frustrated. From this emerges the first hypothesis: (*a*) *that the accident prone child has more frustration-induced aggressive drive than the accident free child.* We should expect that aggressive drive will be expressed in aggressive behavior in a permissive, non-punitive situation.

Aggression Anxiety: The accident prone child is believed to fear the loss of parental love, a form of punishment, as his hostility is assumed to be directed against parental figures. If it is also assumed that he is punished for direct and overt expression of aggression, the second hypothesis is indicated: (*b*) *that the accident prone child has more guilt and fear of punishment at the overt and direct expression of frustration-induced aggressive drive.* (This avoidance drive at the expression of aggression is called aggression anxiety in this paper.) To support this hypothesis aggressive behavior should be inhibited and delayed, and its form should show distortion. It is possible to test this hypothesis in another way, if we equate aggressive drive with the approach gradient, and aggression anxiety with the avoidance gradient. On the basis of the finding that the avoidance gradient is steeper than the approach gradient, it would be expected that when aggression anxiety is extinguished in a permissive situation the accident repeating child will show a greater increase in aggressive behavior and a greater decrease in measures of aggression anxiety than the accident free child.

Family Atmosphere: While the relationships between aggression and aggression anxiety are the central factors to be studied in this investigation, the hypotheses concerning them are based on the antecedent assumptions concerning the authoritarian home environment and frustration of the nurturance drive. On the assumption that the accident prone child comes from a highly controlled environment, which is also one of limited affectionate contacts between adults and children, we may state the third hypothesis: (*c*) *this atmosphere of dominance and command, and limited affectionate contacts is reflected in the accident prone child's perception of reality.* We may, therefore, expect that when a permissive situation is structured on the basis of this experience, there will be a high proportion of commands, threats, and prohibitions, a low proportion of affection, and a high proportion of attempts to solicit affection.

Method

The choice of method was determined by the need to measure both aggressive drive and aggression anxiety. We have proposed for the accident repeating child, however, that fear and guilt will prevent the free expression of aggression, under the assumption of algebraic summation of the approach and avoidance drives. The solution to this apparent dilemma appeared to be the use of a permissive, relatively unstructured situation, a standardized doll play interview. Miller has pointed out that in order to detect the instigation to aggression in cases where even the less overt acts of aggression have been inhibited, it is necessary to reduce the competing instigations (or the aggression anxiety, in this case). It was hoped that in the doll play situation, where expression of aggression is not punished, some extinction of aggression anxiety would take place and the manifestation of aggressive behavior, as well as other behavior, might be studied.

Materials: Two 20-minute standardized doll play interviews contributed the major results of this study. Since it was desirable to limit organizational activity and promote thematic material, particularly of an aggressive nature, a doll house of high realism and maximum organization was designed and constructed. It is a portable, folding doll house whose dimensions are 24 in. wide, 37 in. long, and 4 in. deep when opened in experimental position. It consists of six rooms, in which most of the furniture is glued to the floor. The fantasy support is that of the home environment, and the doll family was a standard one (father, mother, boy, girl, and baby). The dolls used were the Flagg Flexible Dolls, which are made of a flexible, plastic material, easly manipulated by children.

Instructions: The experimenter (*E*) gave the following directions to the children:

> This is a little six-room house. Most of the furniture is glued down and so you can't move it. This is the furniture that you can move. (Point out kitchen chairs, high chair, dining room chairs, piano stool, crib, and dressing table chair.) Here is the kitchen, dining room, the living room, the children's bedroom, the bathroom, and the father and mother's bedroom. You may use the dolls and the house in any way that you want to. The dolls can be bent into any position, and can be moved around. (Demonstrate flexibility of the father doll.)

Opportunity was given at this time for the subject (*S*) to ask about the construction and manipulation of pieces. Then *E* stated:

> Now what we want you to do is to make up a story or a play about this house. It can be any kind of a story you can think of.

Procedure: Following the instructions, *E* recorded the child's play behavior and verbalizations on ruled and squared off sheets of paper, one square being used for each 15-second time unit. An electric clock motor with a revolving cam made a contact every 15 seconds to produce an auditory signal, which indicated to *E* when to move on to a new time unit on the recording sheet. (The *E*'s role was minimal.) Simultaneous recordings of verbalizations were made on a standard wire recorder, which was screened from the child's view. The play behavior was later synchronized with the wire-recorded material with the aid of the auditory signal. These synchronizations represented the complete verbatim transcriptions of the play sessions, which could then be scored.

Doll Play Measures: The scoring system which was developed to measure doll play behavior was based on the scoring categories developed in the Iowa Studies and on the findings of Levy. Those scoring categories yielding the results reported in the article are as follows:

Aggression. This category, designed to test the hypothesis concerning aggressive drive, included doll and subject attitudes, feelings, intentions, and actions of an injurious, critical, or destructive nature.

Aggression Anxiety. a. Form of aggression. The subcategories of verbal aggression, verbal description of aggression and action aggression were separately scored to reveal differences in the amount of inhibition.

b. Latency of aggression. The delay in expressing aggression was measured by the number of time units preceding the expression of the first aggressive act in doll play.

c. Inhibitions to aggression. This category included subject and doll denials of aggression, self-warnings against committing acts of aggression, requests for reassurance, and two subcategories of tangential activity. Tangential play was scored when *S*'s doll play did not appear to be a story with "living character roles"; tangential behavior, when *S* asked about, played with, or explored material in the experimental room other than the doll house and the dolls themselves.

Family Atmosphere. a. Authoritarian atmosphere. Commands, prohibitions, and threats were scored in this category.

b. Affection. Doll and subject attitudes, feelings, intentions, and actions of an affectionate, friendly, generous nature, or happy mood in general, were scored in this category.

c. Solicitance of affection. Requests for help or affection by either subjects or dolls were scored in this category.

Additional. a. Stereotyped thematic play. This included thematic action or phantasy

characteristic of routines carried on in the usual home situation, appropriate to the time, place, situation, and characters involved.

b. Nonstereotyped thematic play. All thematic action or verbalized phantasy concerning situations outside of the usual routines and not classified elsewhere were scored in this category.

c. Experimenter interaction. This category was defined as *E*'s requests and replies to *S*.

d. Activity level. This was measured by cumulating the total amount of doll play behavior.

The method of scoring adopted was one of complete coverage. The scores were made in terms of behavior units. A behavior unit was determined by the completion of a goal-end action, and goal-end actions were defined in terms of relevancy to the above scoring schema. All identifying data were removed from doll play protocols before scoring.

Scoring Reliability: Agreement between scorers. An independent scoring was made by an experienced clinician of five play-session protocols chosen at random. Reliability was defined in terms of the number of agreements and number of disagreements found between *E* and the independent scorer. An agreement was noted when the exact scoring subcategory was indicated for a time interval. Disagreements due to confusion with another subcategory were counted one-half against the first subcategory and one-half against the second one. The formula for computing reliability was, therefore:

$$\frac{\text{Number of agreements between observers A and B}}{\text{Number of agreements} + \text{one-half the disagreements}}$$

The agreements for the totals of each of the categories ran from 43.6 per cent to 95.3 per cent, and the mean reliability was 68.2 per cent.

Self-agreement. The experimenter rescored four play sessions selected at random, more than six months after the original scoring. The agreement for the totals of each of the categories ran from 60.5 per cent to 95.6 per cent, and the mean reliability was 80.7 per cent. These percentages of agreement compare very favorably with those reported in the doll play literature, in view of the fact that they are computed on a small sample according to a rigorous criterion of agreement.

Subjects: The accident repeating children studied in this investigation were located through the inpatient and outpatient records of five major hospitals in the City of Rochester, New York. Only those five- to eight-year-old children who had had a record of three or more major or minor accidents in the four-year period prior to study (January, 1946, to January, 1950) were selected for study. Children having epilepsy, mental deficiency, and organic brain disease were omitted. The accidents of the remaining eligible children were carefully screened to ascertain that they were not due to the carelessness of parents or other adults. Of the 2,649 children found to have accident records, only 53 children met the criteria. Twenty-one of these children were omitted for various reasons. No apparent selection factor which might differentiate these 21 children from the other 32 was discovered.

The 32 accident *S*s who were included in this study ranged in chronological age from 5 years, 8 months to 8 years, 10 months, with a mean age of 7 years, 2 months. Their mean mental age equivalent on the Terman Vocabulary Test was 7-2, with a range from 4-0 to 10-9. These 32 children had had a total of 110 accidents during the period surveyed, an average of 3.4 accidents per child, with a range of from 3 to 6 accidents. Falls (in terms of event) and lacerations (in terms of injury) comprised the greatest number of accidents. These *S*s are, in general, a minor injury population.

The 32 control children were paired with the experimental children on the basis of sex, chronological age, and mental age equivalent scores on the Terman Vocabulary Test, and were selected from the same grades and schools as the experimental children. The control children were an accident free group, determined by checking school health records, public health nursing records, and

the survey records of this study. The control *S*s ranged in chronological age from 5 years, 8 months to 8 years, 9 months, with a mean age of 7 years, 1 month. Their mean mental age equivalent was 7-4, with a range from 4-6 to 11-3.

Experimental Design: The children were seen in 14 public schools and 7 parochial schools in the city of Rochester, and in 2 schools in Brighton. Arrangements to see the children were made with the principals in order to keep the nature of the investigation confidential from the teachers and children. The control and experimental children were first paired by means of the Terman Vocabulary Test. Subsequent to this the Rosenzweig Picture-Frustration Study, Children's Form, was administered.[4] The next two sessions included sessions one and two of the standardized doll play interview. In all cases, the control child was seen the same number of times as the experimental child. In no case was there *less* than 24 hours between the Rosenzweig Picture-Frustration Study and the first doll play session, or between the first and second doll play session, and there was never *more* than a week between doll play sessions.

Results and Discussion

Aggressive Drive: Table 1 presents the totals for doll play measures designed to test the hypotheses relating to aggressive drive and aggression anxiety. The measures were scored both as percentages of total doll play behavior and in terms of the number of time units in which the behavior occurred. The results indicate that the accident repeating children studied in this investigation demonstrated more aggressive behavior in doll play than the accident free children. These findings are in the direction of confirming the hypothesis concerning aggressive drive as stated above.

Aggression Anxiety: The results testing the aggression anxiety show some inconsistencies. The accident repeating children demonstrated significantly more of their aggression as verbal aggression and tended to show a smaller percentage of their aggression as action aggression than the accident free children. These results suggest the attenuation of the intensity of aggression, possibly as a result of aggression anxiety, in the expected direction. However, the accident free children showed more inhibitions and significantly longer latency than the accident repeating children. This was contrary to prediction, as these were considered to be measures of avoidance of the expression of aggression.

Table 2 presents the results for changes from session one to session two, a comparison designed as a further test of the aggression anxiety hypothesis. It was predicted that aggression anxiety would be extinguished in a permissive situation more quickly for the accident repeaters than for the accident free. Although no significant changes were found, they were all in the predicted direction. The accident repeating children demonstrated a greater increase in aggressive behavior from session one to session two than did the accident free children. The accident repeating children also showed a greater decrease in latency from session one to session two than did the accident free children. For form of aggression to be in the direction of supporting the aggression anxiety hypothesis, we should expect that with extinction of aggression anxiety in a permissive situation the verbal forms of aggression (less intense forms) would decrease more for the accident repeaters than for the accident free, while the action forms (more intense forms) would show greater increases for the former. While the trend for verbal aggression alone did not follow this hypothesis, those for verbally mediated action aggression, total verbal aggression, and action aggression are in the expected directions. It is probable that significant differences for these changes were not found because two sessions were not enough to extinguish aggression anxiety completely.

Aggression Anxiety Inconsistencies: The

[4] The results obtained with the Rosenzweig Picture-Frustration Study, Children's Form, will not be reported since they showed no significant differences which could not have been obtained by chance alone.

TABLE 1.—DOLL PLAY MEASURES OF AGGRESSION AND AGGRESSION ANXIETY FOR TWO TWENTY-MINUTE STANDARDIZED DOLL PLAY INTERVIEWS

(N = 32 pairs of children)

Doll play measures	*Accident repeaters*	*Accident free*	*Difference*	*Sigma mean diff.*	*t*	*p**
Aggression						
Proportions	.053	.029	+.025	.012	2.08	.025
Time units	13.75	6.85	+6.91	3.06	2.26	.025
Aggression anxiety						
Form of aggression**						
Verbal	.424	.280	+.144	.094	1.53	.10
V. action	.183	.152	+.031	.053	.58	.30
Total verbal	.610	.431	+.179	.095	1.88	.05
Action	.252	.301	−.048	.085	.56	.30
Latency	78.06	102.59	−24.53	11.43	2.15	.025
Inhibitions						
Proportions	.271	.298	−.026	.038	.68	.25
Time units	59.00	64.63	−5.63	6.94	.81	.25

* p values are for only one tail of the distribution.
** Computed as a proportion of total aggression.

limited and inconsistent support of the aggression anxiety hypothesis may be explained in several ways. It is possible that inhibitions and latency are not "pure" measures of aggression. Other research suggests that tangentiality (inhibitions) and latency (delay) are correlated with aggressive drive, as well as with aggression anxiety. An alternative explanation may be that the aggression anxiety hypothesis was overweighted in the formulation of predictions for this study. This might have occurred by basing predictions on information in the literature concerning the personality dynamics of adult accident *S*s, because of the limited number of publications on children with repeated accidents. Developmental differences may, therefore, account for the difference in findings. One would not expect well-developed superego inhibitions in children of this age, considered to be the major dynamic basis for inward turning of aggression in the adult accident prone individual. The differences found may also be explained on the basis of differential developmental ability to discriminate reality restrictions, i.e., we may expect experience differences between children and adults in their ability to evaluate their own physical limitations.

It is the writer's feeling that the inhibition hypothesis was overweighted in the original formulation of this study. The accident repeating children demonstrate more aggressive drive, but only somewhat less aggression anxiety than the accident free children. They showed less inhibitions, in terms particularly

TABLE 2.—CHANGES IN DOLL PLAY MEASURES FROM SESSION ONE TO SESSION TWO

(N = 32 pairs of children)

Doll play measures	MEAN CHANGE* *Accident repeaters*	*Accident free*	*Difference*	*Sigma mean diff.*	*t*	*p***
Aggression						
Proportions	−.040	−.023	−.017	.018	.94	.20
Time units	−3.75	−2.65	−1.09	1.78	.61	.30
Latency	+11.56	+6.97	+4.59	7.82	.59	.30
Form of aggression						
Verbal	+.005	+.012	−.008	.108	.08	.50
V. action	+.007	−.044	+.051	.058	.88	.20
Total verbal	+.032	−.045	+.077	.115	.67	.30
Action	−.119	−.034	−.085	.102	.83	.25

* A mean change from session one to session two is an increase when the sign is negative and a decrease when the sign is positive.
** p values are for one tail of the distribution.

of tangentiality, and a shorter delay in expressing aggression. Some of the evidence in the direction of confirming the aggression anxiety hypothesis suggests that there may be some anxiety surrounding the expression of aggression. Although the accident repeating children expressed more total aggression than the accident free children, a greater percentage of their aggression is verbal rather than action in comparison with the accident free children. This suggests that there is some attenuation of the intensity of their expression of aggression.

Authoritarian Atmosphere: Table 3 includes the results concerning all family atmosphere categories. While the results for measurement of Authoritarian Atmosphere in doll play showed no significant differences, they were consistently in the direction of the accident repeating children showing more commands, threats, and prohibitions than the accident free children. In view of Jeffre's finding that this kind of doll play behavior appears to reflect the reality of the home environment, these results suggest that accident repeaters may come from an authoritarian atmosphere.

Affection and Solicitance of Affection: The results for Affection and Solicitance of Affection show small and statistically insignificant differences and are not consistent.[6] The results for Solicitance of Affection are in the predicted direction, but those for Affection are not. The trends indicate more affectionate behavior as well as more solicitance of affection for the accident repeaters than for the accident free. One explanation of the divergence of findings from prediction might be that these measures are not measures of reality representation, i.e., they do not reflect the child's accurate perception of his family life. Instead they may mirror wish fulfillment of needs. When these categories are considered together, they are similar to Sears' dependency measure. There is some support for a wish fulfillment explanation of these measures in Sperry's finding that aggression and dependency maintain a balance in doll play. Thus, as the children in this study showed increases in aggressive behavior from session one to session two, they also increased in all behavior having to do with affection, possibly as a bid for appeasement or for satisfaction of dependency needs.

Additional Findings: The results for additional categories of scoring included in part to allow for complete coverage of doll play behavior are presented in Table 4. (Since no hypotheses were presented for this material, p is given for two tails.) They indicate that the accident free children tended to engage in more Stereotyped Thematic Play (representative of reality in normal home routines), while the accident repeating children showed for time units significantly more Nonstereotyped Thematic Play (nonreality play, which often tended to the bizarre). The accident repeating children also demonstrated more total doll play behavior (Activity) than the accident free children. These findings cannot

[6] It is possible that these categories suffered most from unreliability of scoring as they were most difficult to differentiate. The percentages of agreement were lowest for Solicitance of Affection.

TABLE 3.—DOLL PLAY MEASURES OF FAMILY ATMOSPHERE FOR TWO TWENTY-MINUTE STANDARDIZED DOLL PLAY INTERVIEWS

(N = 32 pairs of children)

Doll play measures	*Accident repeaters*	*Accident free*	*Difference*	*Sigma mean diff.*	*t*	*p**
Authoritarian atmosphere						
Proportions	.022	.013	+.008	.006	1.33	.10
Time units	6.84	4.40	+2.44	2.02	1.21	.15
Affection						
Proportions	.043	.042	−.002	.011	.18	.45
Time units	12.34	11.03	+1.31	3.05	.43	.35
Solicitance of affection						
Proportions	.020	.020	+.001	.004	.25	.45
Time units	5.50	5.44	+.06	1.37	.04	.50

* p values are for only one tail of the distribution.

TABLE 4.—ADDITIONAL DOLL PLAY MEASURES FOR TWO TWENTY-MINUTE STANDARDIZED DOLL PLAY INTERVIEWS
(N = 32 pairs of children)

Doll play measures	*Accident repeaters*	*Accident free*	*Difference*	*Sigma mean diff.*	*t*	*p**
Stereotyped thematic						
Proportions	.416	.468	−.053	.048	1.10	.30
Time units	85.88	92.40	−6.53	7.33	.89	.40
Nonstereotyped thematic						
Proportions	.097	.074	+.022	.020	1.10	.30
Time units	23.22	14.65	+8.56	3.78	2.26	.05
Experimenter interaction	.044	.046	−.002	.002	1.00	.40
Activity	428.66	371.31	+57.34	30.86	1.86	.10

* p values are for both tails of the distribution.

be explained on the basis of greater incitement of the experimental group to activity as the experimenter did not interact to a significantly different extent with the accident repeaters (see Experimenter Interaction in Table 4).

Family and School History: Some casual findings about family and school history noted while collecting the data suggested that the experimental group may represent a sample different from the control population of five- to eight-year-olds. (Social histories were not obtained from families because of the promise to withhold the medical information used in the selection of accident repeaters.) It was noted that while 13 of the 32 accident repeating children had transferred at least once from one school to another, only one of the 32 accident free children had done so. When these data were submitted to the chi-square test of independence, a chi square of 12.74 was found, significant at the .01 level. While seven of the accident repeating children came from broken homes, only one of the accident free children did. These data yielded a chi square of 5.14, significant below the .05 level.

Of the 22 pairs of public school children seen, 9 of the accident repeating children were known to the home and school counselor, while only 2 of the accident free children were so known. The chi square for these data is 5.94, a finding which is significant below the .02 level.

The accident repeating children tended to come from larger families and to be later in birth order. The average number of siblings for the experimental group was 2.69 while that for the control group was 1.50. The average birth order for the experimental group was 2.81 while that for the accident free group was 1.59.

Implications of Findings: The results of the family atmosphere categories indicated that the accident repeating children showed more commands, threats, and prohibitions in doll play than did the accident free children, and that they also demonstrated more behaviors of the Affection and Solicitance of Affection categories. Whether we interpret these findings as representing the reality of family life for them, or, in the case of the Affection categories, as representing wish fulfillment for dependency needs, it is possible to draw one general conclusion. Accident repeating children reflect more intense kinds of interaction between doll figures than do accident free children. Less of their play is a of stereotyped nature, suggesting that they are less reality oriented than accident free children. They also demonstrate a higher activity level, in agreement with other investigators' findings that accident repeaters have a high degree of physical strength.

These findings are in accordance with the indications that accident repeating children come from home environments suggesting greater social disorganization than accident free children. The social findings indicated above (that they tend to come from broken homes, from families which move around often enough so that the children change schools relatively frequently, to be later in birth order, and to come from larger fami-

lies) suggest less social stability, greater mobility, and more social disorganization. That these factors should be reflected in disorganized play and less play representational of normal and family activities is not surprising, if one accepts a reality representation explanation concerning doll play.

At the present time, it cannot be conclusively shown from these results that there is any cause and effect relationship between personality characteristics and the accident repeating tendency. Indeed, it may be felt by some that the accident tendency is due to a lack of supervision accompanying the social disorganization rather than to the personality characteristics resulting from those family interactions. It is interesting to note in this connection, however, Fuller's finding that accident repeating nursery school children tended to get into injury-laden situations in a carefully supervised nursery school environment. If our findings on the accident repeaters in this study are valid, then greater aggression and greater activity may provide the motivation for the selection of such situations. Further research would need to verify the family, social, and personality characteristics and to study the nature of the accident environment more carefully to determine to what extent the accidents of accident repeaters are "accidental."

Summary

This investigation was designed to test the hypotheses that accident prone children have greater aggressive drive, as a result of nurturance frustration in an authoritarian home environment, and greater aggression anxiety, as a result of punishment for expression of aggression, when compared with accident free children.

Thirty-two children of five to eight years of age who had three or more accidents during the prior four-year period were selected from the records of five Rochester hospitals. Thirty-two accident free children were matched with them for age, mental age, and sex from the same schools and grades.

The results which are reported are from the administration of two 20-minute standardized doll play interviews. The children were asked to make up a story in response to a six-room doll house of maximum realism and organization. The standard doll family included a father, mother, boy, girl, and baby. The *E*'s role was one of minimal interaction. Synchronized protocols of recorded verbalization and of behavior were made. The doll play behavior was scored for categories both as percentages of total doll play behavior and in terms of the number of time units in which the behavior occurred.

The major results found were as follows:

1. Accident repeaters engaged in significantly more aggression in doll play than did accident free children.

2. Accident repeaters tended to show less inhibitions (tangentiality and need for reassurance) than accident free children.

3. Accident repeaters showed significantly less delay in expressing aggression than accident free children.

4. Accident repeating children showed significantly more verbal aggression than accident free children and tended to show less action aggression.

5. Accident repeaters tended to show greater increases in aggression and greater decreases in measures of aggression anxiety from session one to session two than accident free children, but the differences were not statistically significant. These findings suggest greater extinction of aggression anxiety for the accident repeaters than for the accident free children.

6. The accident repeaters tended to show more, but not significantly more, commands, threats, and prohibitions in doll play, and more instances of affection and solicitance of affection than accident free children.

7. Accident repeaters showed more activity in doll play, and significantly more nonstereotyped (unrealistic) thematic play. They tended to show less stereotyped (realistic) thematic play.

8. The accident repeaters were noted to have come from larger families, to be somewhat later in birth order, to have come more often from broken homes, to have transferred schools more frequently, and to be more often known to home and school counselors in the public schools.

The evaluation of psychiatric factors reported by this study is a clinical rather than a statistical examination of the accident repeater for the presence or absence of significant psychological disorder. Like so many psychiatric evaluations, however, it lacks the methodological rigor required for any clear-cut acceptance or rejection of the hypotheses. The sample lacks representativeness—only 32 out of 2649 eligible multiple-accident children met the criteria for study. The report does not provide sufficient information as to how this group was selected or how it compared with the rejected cases; the matching of experimental and control groups is inadequate, and the data show that these two groups differed in family and school histories. It may well be that the more highly disorganized home background of the accident group could independently account for both the observed personality differences and the occurrence of accidents. Finally, the reliability and validity of both the accident criteria and the psychological evaluation are not established. Because shortcomings of this type characterize the bulk of the clinically oriented accident-proneness literature, the concept still requires further study.

THE ACCIDENT-PRONE AUTOMOBILE DRIVER

—W. A. Tillmann, M.D., G. E. Hobbs, M.D.

This widely quoted study is typical of much of the research on accident proneness. Its authors studied groups of Canadian taxi drivers with high and low accident rates in terms of a number of social and psychological characteristics. They considered the differences in personality structure as being indicative of accident proneness. On this basis, they claimed that the accident-prone individual is characterized by marked intolerance of and aggression toward authority, dating back to early childhood. In comparison with a group of 100 accident-free individuals, a group of 96 drivers with a record of four or more accidents was found to contain many more individuals known to social and law-enforcement agencies. From these results, the authors conclude that "a man drives as he lives."

Although this study illustrates interestingly that automobile driving habits reflect an individual's general behavioral attributes, it does not really test accident proneness as a psychological hypothesis. It provides no evidence that the social and psychological differences found between the high- and low-accident groups represent stable, inherent, personality factors. It demonstrates that people who have accidents differ from those who do not, but one can conclude very little from this about the nature of the accident-causation process.

IT HAS BEEN ESTABLISHED for many years that when the frequency distribution of accidents in any group is analysed there are a number of individuals who have a greater proportion of accidents than can be explained on chance alone. The personality of this group has been described and it has been suggested that this is the determining factor that makes them more accident-liable.

In this study the existence of accident-prone drivers among bus drivers has been established from a statistical point of view.

[Reprinted, with permission, from the *American Journal of Psychiatry*, *106*:5:321-331, November 1949. Portions of the text and 1 figure have been omitted.]

A group of taxi drivers has been interviewed to determine personality characteristics and these findings have been compared with the driving records. The high and low accident groups differ markedly in their personality characteristics. The high accident group shows marked intolerance for, and aggression against, any authority, dating from early childhood. The origin of this aggressiveness is to be found in an unstable home background. In many instances this personality feature shows up in antisocial behavior in the individual's life history. The high accident record is one manifestation of these personality characteristics. To determine if these same characteristics were to be found within the general driving population, 96 drivers with a history of 4 or more accidents in the London district were checked by social and law enforcement agencies. These were compared with a control group of 100 accident-free drivers. Sixty-six percent of the high accident group were known to these agencies in contrast to 9% of the control group. The findings are similar to those noted in the taxi driver group. Thus, within the general driving population, too, there are many individuals whose high accident record is related to personality characteristics that influence their driving in such a manner as to make them accident-liable. The personality characteristics and social background of high accident drivers must be considered in any over-all attack on the automobile accident problem. This can be done at a sufficiently superficial level without specialized psychiatric training.

* * *

Social and Psychological Characteristics of the Accident-Prone Driver

Study of a Taxi Driver Group: The personality characteristics of the accident-prone group have been adequately described by Dunbar. Her studies were carried out on fracture patients in hospital. The outstanding characteristics of her largest group were aggressiveness, impulsiveness, and intolerance of social or family limitations on their behavior. From a psychiatric point of view they would be classified as mild psychopathic personalities.

We had planned to study the personalities of the high accident bus drivers. Circumstances over which we had no control (labor and management problems) made this impossible. However, the local taxi firms offered an excellent opportunity for this type of study. For several years they have been plagued with high accident rates and resulting high insurance costs, etc. They welcomed any study that might offer them information on this problem, and the management did everything humanly possible to assist in this study. It soon became apparent, however, that a taxi firm, as organized in our city, was a loosely knit organization with little central control and with little detailed knowledge of the activity of the individual driver. The records of accidents were largely nonexistent. However, considerable information was obtained from the insurance company for the firm, the memory of the management, and the various drivers as to their own experience and that of other drivers. With the exception of the insurance firms, all information was dependent upon the memory of the individuals. It was not possible to carry out an accurate statistical study of the accident rate in terms of mileage as had been done with the bus drivers. However, by pooling the information from various sources, the drivers could be classified roughly into the high, low, and average accident frequency groups.

One of us (Tillmann) spent the better part of 3 months in constant association with these drivers, riding in their cars, talking with them while they were waiting for calls, checking one man's story against the interpretation of his friends and associates, etc. Some 40 drivers, constituting the high and low accident groups, were interviewed in this manner. For each driver a personal history covering the parental background, childhood, and adolescent history, and subsequent adult adjustment was obtained. In addition, information was obtained from the police, Juvenile Court, and social agencies.

Only 3 instances of actual falschood were encountered and these were in the high accident group. In addition, note was made of the cleanliness and the presence of undue accessories in the individual driver's car. Considerable time was spent in group conversation with the men. This offered an excellent opportunity of observing his adjustment to, and standing in the estimation of, his friends and associates. We did not feel that we obtained any accurate impression of his driving ability since all drivers were acutely conscious that they were being observed. It was our feeling that this approach was more informative than a formal interview, even under the most satisfactory conditions. It was our impression that certain drivers, particularly those with a higher accident record, tended to minimize the number of accidents and to exaggerate the magnitude of their driving experience. The age distribution of the 2 groups was similar. This is important since our findings amply confirm the observations made frequently that drivers from the 20 to 24 age groups have many times the number of accidents of the older age groups.

In the classification of the accidents, no effort was made to determine if the driver was at fault. We would be in agreement with Farmer who states that those with the high accident rate appeared to have more blameless accidents than did the low accident drivers. The fault of the accident-prone driver is that his driving habits leave him little chance for protection against any unexpected happening.

The findings in a group of 20 high accident taxi drivers as compared with 20 low accident drivers are shown in Table 1. It is interesting to note that although the number of drivers interviewed is relatively small the differences noted are statistically highly significant, except in the case of the employment record. On the basis of this interview we have drawn up the personality profiles of the high and low accident groups.

The High Accident Taxi Driver[3]

Family History.—The parental divorce rate is high. Gross disharmony among the parents, along with one or both parents being described as excessively strict, was frequently found. The father was often described as a poor provider, with a record of being an excessive drinker and having very few friends.

Childhood Adjustment.—Eleven gave a history of childhood instability of an aggressive type, such as temper tantrums, fre-

[3] In this outline we have followed Dunbar closely.

TABLE 1.—PERSONALITY SURVEY ON GROUP OF TAXI DRIVERS

Personality	*Characteristics*	*High accident group, 20 men*	*Low accident group, 20 men*	*Statistical significance* χ^2
Birth place	Urban	15	15	—
History of parents	Parents divorced	6	1	4.63
	Excess strictness and disharmony	13	5	6.28
Neurotic traits in childhood life	Excess childhood phobias*	11	5	4.48
	Excess aggression in childhood†	11	0	23.60
School adjustment	Completing grade school	15	15	—
	Truancy and disciplinary problems	12	2	10.98
Employment record	Five or more previous jobs	13	7	3.60
	History of being fired	10	4	3.98
Armed service record	Member of armed service	15	9	—
	Frequent A.W.L.'s	11	1	8.60
Marital status and sexual adjustment	Married	8	11	—
	Admitting sexual promiscuity	8	2	4.00
Social adjustment	Having two or more hobbies	9	17	8.50
	Admitting bootlegging on job	14	3	12.20
	Conscious of physique	11	3	5.40

* Enuresis, fear of fights, dark, deep water, excessive daydreaming, etc.
† Leader of gang, bully, temper tantrums, Juvenile Court record, etc.
When $P = .05$, $\chi^2 = 3.84$.

quent fights, bully characteristics, leader of a gang, and frequent appearances at the Juvenile Court. An equal number gave a history of the nonaggressive type of childhood anxiety such as enuresis, fears of fights, dark, deep water, excessive daydreaming, etc.

School Adjustment.—Their academic standing at school was average. There were frequent records of truancy, disciplinary infractions, etc. They showed interest in sports involving group activity and bodily contact, such as rugby, etc. There was a strong interest in body build. Most left school to seek independence.

Work Record.—The work history was that of frequent short-time employments, the man often stating that he had been discharged. The adjustment with employers was usually poor. This group is usually satisfied to remain with its present employment as it offers the line of least resistance and allows freer play of their aggressiveness than do more settled routine occupations.

Social Adjustment.—These were individuals with many acquaintances but few friends. Their emotional attachments were superficial and varied from day to day, as their impulsiveness dictated. In a group they always attempted to be the center of the stage. Interest in hobbies was rarely found. Their main activities were found in the field of sports, drinking, gambling, and occasionally dancing.

Sexual Adjustment.—This group, if married, tended to be unfaithful to their wives and showed little interest in, or sense of responsibility toward, their families. A history of promiscuity was common, but the V.D. rate was not particularly high. There was little anxiety or feeling of guilt over sexual misdemeanors.

Previous Health.—There was a story of the usual childhood diseases. Personal injuries resulting from accidents were common; otherwise the health could be considered as good. There were few functional complaints.

Behaviour Patterns.—As a group they behaved in an immature manner. Filthy language was used freely. They were good conversationalists, but took advantage of every situation to try to impress others with their importance. They showed no concern over their problems. Personal dress tended to be eccentric.

Driving Habits.—As a group they were easily distracted while driving. They tended to become readily annoyed at other motorists on the road, often criticising their own driving mistakes in others. Horn honking and racing other cars away from a stop light were their specialties. As a group they showed a marked interest in the mechanical aspects of the car, and expressed no concern over the possible mechanical limitations of the automobile. Their cars were often untidy, dirty, and contained flashy accessories. They tended to be discourteous to their passengers.

Philosophical Outlook.—Their thinking was dominated by fatalistic ideas and interest in the material aspects of life. They disliked discipline, abhorred routine, and expressed a strong desire to be their own bosses. They considered only the immediate future, thinking only of the satisfactions of each day.

The Taxi Driver with the Low Accident Frequency

Family History.—Parental divorce rate was low and harmony was usually considered adequate. Parents were usually described as firm, understanding individuals, and were considered to be stable, well-adjusted personalities.

Childhood Adjustment.—Features of mild instability were occasionally present, but these were always of the nonaggressive type. Tendencies most frequently noted were overt fears of the dark and heights, fear of fights, and excessive shyness. They were usually followers of a gang. A history of active delinquency was rarely obtained.

School History.—The academic standing was average. In no instance was there a history of truancy. Interest in group sports was common. The driver usually left school because family finances demanded it.

Work Record.—There was usually a history of long periods of employment with adequate adjustment to previous employers.

The drivers frequently expressed a desire to better their situation in life by changing from their present occupation and seeking a more stable livelihood.

Social Adjustment.—These drivers usually possessed a group of friends. As individuals they tended to be quiet and conservative when in a crowd. Usually they expressed an interest in hobbies such as gardening, sports, church organizations, etc. This is one of the most outstanding differences between these and the high accident group. If they drank at all they tended to be moderate drinkers and they seldom gambled.

Sexual Adjustment.—If married, these men were faithful to their wives with a marked interest in their home and family. Sexual promiscuity was not common and if present it was associated with a worry about their misdemeanors.

Previous Health.—There were the usual childhood diseases, but it appeared that this group had a higher incidence of sickness, such as minor respiratory infections, etc., than the accident repeater group. Functional complaints were relatively common and they tended to be health conscious.

Behaviour Patterns.—Usually they were quiet, reserved individuals with whom it was difficult to establish rapport. They were conscientious about their work and tended to brood considerably over their problems.

Driving Habits.—These men were serious while driving and often refused to talk. They tended to be courteous to other drivers on the road and stated that they were conscious of the fact that the other driver might do the wrong thing. They appreciated the possible mechanical limitations of their vehicle. As a group they did not show strong mechanical tendencies, but their cars were usually kept clean and conservative in appearance. In contrast to the high accident group they were courteous to passengers.

Philosophical Outlook.— This group seemed to be concerned about the welfare of others. They gave serious consideration to the difficulties of the future and adjusted well to any discipline involved in their occupation.

* * *

Thus it would appear that in the taxi driver group there is a characteristic personality pattern that is associated with a high or low accident record. The personality with a high record is characterised by aggressiveness and inability to tolerate authority either at the parental or community level. This would appear to have its origin in the home background of the individual. This aggression against authority shows up in an objective way in the frequency with which this group comes in conflict with the recognized community methods of obtaining law and order. The low accident group is made up of serious, stable, well-adjusted individuals with well-integrated home backgrounds.

Social Adjustment of the High Accident Group in the General Driving Population

The information obtained on the personality of the high accident driver group throws considerable light on the problem of the causation of multiple accidents as applied to this group. However, if one attempts to apply this information to the general population, there is the obvious criticism that taxi drivers are a highly selected group and that one might encounter personalities and social difficulties that would not necessarily be present in the general driving population. Therefore, our next procedure was to obtain the name and address of 96 male drivers in the London district who had suffered from 4 or more automobile accidents. This information was obtained from the Ontario Department of Highways. Only accidents of 50 dollars or more damage were reported to this department. All accidents are reported whether the driver is apparently at fault or not. As a control group we also obtained the names of 100 drivers in the same district. This selection was unbiased except that they were accident-free and of the same age and sex as the high accident group. The names of both groups were submitted to the Juvenile Court, the Adult Court for records other than the automobile accidents, to the public health agencies and venereal disease clinics,

and to three social service agencies. These were the Family Service Bureau, which handles difficulties of a family nature, and to the 2 Children's Aid Societies, Catholic and Protestant. In addition the names were checked by the local credit bureau. Here we counted as positive a name that was known more than once in this bureau. A survey of this type does not allow the fine type of personality analysis that is possible with personal interviews used in the taxi driver survey, but it does have the advantage of being quantitative and not open to influence by possible bias on the part of the observer. It was our feeling that if we received the history of frequent contacts with these various agencies this was indicative of a similar type of personality as that found among the taxi drivers by the interview method.

In reply to our inquiries 66% of the high accident group were known to one or more agencies. Among the 100 accident-free drivers there were only 9 who were known to any agencies and in no instance was a person known to more than one.

In the high accident group 2 persons were known to all sources, 3 were known to 4 sources, 9 to 3 sources, 16 to 2 sources, and 32 to 1 source. In the high accident group the credit bureau had contacted 34.3%, the social agencies 17.7%, the public health and venereal disease clinic 14.4%, the Adult Court 34.3% exclusive of traffic charges, and the Juvenile Court 16.6% (Fig. 2). In the low accident group, on the other hand, the credit bureau knew 6 individuals, and the social agencies, Adult Court, and the Juvenile Court each had had contact with one individual.

Thus it would appear that social maladjustment of various types is to be found quite as frequently among the general driving population with a high accident record as among the high accident taxi drivers and that one is justified in feeling that the same pattern exists in both groups.

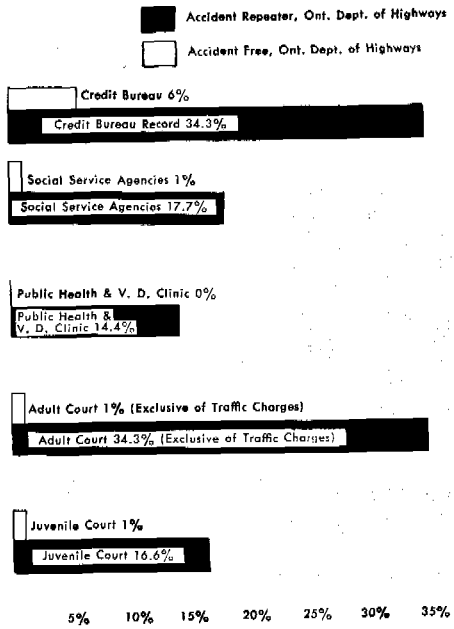

FIG. 2. Social records of 96 accident repeaters and 100 accident-free drivers.

SUMMARY AND CONCLUSIONS

In this study the existence of accident-prone drivers has been demonstrated in the records of accidents from a bus company extending over a period of 6 years. The frequency of appearance of the same individual in the high accident group in multiple years has been noted. It has been shown that because of their high accident rate their importance in contributing accidents far exceeds their numbers. In other words, a few drivers account for a disproportionate number of accidents year after year.

A group of high and low accident drivers in a taxi firm have been interviewed and the differences in the personality and background of the 2 groups have been noted. It has been demonstrated that the high accident taxi driver most frequently comes from a home marked by parental divorce and instability. During childhood his life is marked by evidence of instability and disrespect for organized authority. As a result he has often encountered difficulty with the school authority and frequently has been before the Juvenile Court. In adulthood his occupation record is marked by frequent short-term em-

ployment and his connections with any firm are frequently terminated by the employer. He has a police record apart from traffic violations much more frequently than those within the low accident group. His personal life is marked by the same evidence of social disregard as noted in the other aspects of his life. For this reason he is frequently known to various social agencies such as the Children's Aid Societies, the Family Service Bureau, and the Public Health Department. He is an individual who places all emphasis on material values and who acts only with thought for immediate satisfaction without any concern for tomorrow. His driving is marked by the same tendency of aggressiveness, impulsiveness, and lack of thought for others and the disrespect for authority that was noted in his personal life.

To determine if there was evidence of the same type of personality involved in frequent accidents within the general population, the names of 96 drivers with a record of 4 or more accidents was obtained from the Ontario Department of Highways. These were compared with a comparable group of 100 accident-free individuals. These were checked for contact with the various health, social, and law enforcement agencies within our area. The findings for the high accident members in the driving group were essentially the same as those encountered in the taxi driver group.

It would appear that the driving habits, and the high accident record, are simply one manifestation of a method of living that has been demonstrated in their personal lives. Truly it may be said that a man drives as he lives. If his personal life is marked by caution, tolerance, foresight, and consideration for others then he will drive in the same manner. If his personal life is devoid of these desirable characteristics then his driving will be characterized by aggressiveness and over a long period of time he will have a much higher accident rate than his more stable companion.

* * *

In addition to being theoretically inconclusive, this article suffers from many of the weaknesses of other studies that compare individuals who have high accident rates with those who have low rates. For example, the accident classifications, as pointed out by the authors, were largely dependent upon the memory of the individual; the number of cases in the primary study was too small (20) to permit the necessary comparisons on background characteristics; there was no determination of accident responsibility; there was no control on exposure; the personality measures were of unknown reliability and validity; accident-incurring and accident-free groups were not matched on other possible explanatory factors such as driving habits. These methodological inadequacies require us to view the present data with extreme caution. Nonetheless, the findings are of sufficient theoretical and practical interest to justify carefully designed work along similar lines. (See also McFarland, Chap. 2.)

Finally, the recent work of Cresswell and Froggatt provides the most nearly definitive review of the accident-proneness concept and literature published to date.[7] It should be consulted by all those concerned with accidents from any point of view. Their work, moreover, reports the results of a highly sophisticated analysis of the accidents of a large population of bus drivers. On the basis of this analysis they conclude that their "data do not support the contention that there were [comparatively] many, if indeed any . . . drivers in the population . . . who were 'accident prone'." This is but the latest evidence that the burden of proof that there are "accident-prone" individuals must rest with those who defend the concept, since this most definitive study fails to provide evidence that such individuals exist.

CONCLUSION

The foregoing studies indicate that accident proneness is a psychological abstraction based upon a statistical frequency. As often happens when a statistical distribution is given theoretical significance, the concept quickly assumed much more meaning than was originally intended. The unacceptability of the concept of accident proneness in a technical sense should not, however, be taken to mean that personal factors do not play an important role in accidents. In fact, rejecting the concept of accident proneness, with its implication of a global personality trait, forces one to search for many different psychological factors and their significance in given environmental circumstances.

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