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ABSTRACT

In a variable distance 10-trial ringtoss, it was found that success required that a subject exceed his expected score. Therefore, the probability of success was the probability of exceeding the expected score on the 10 throws (Ps10); and this is shown to be different from the probability of scoring a ringer in a single throw (Ps1) from the same distance. Earlier results presented in support of Atkinson's theory of risk-taking behavior used the same experimental method but tested the theory against Ps1. The same data do not support the theory when analyzed against Ps10. It is suggested that in a multiple trial task, Ps1 represents not a probability of success, but a long term performance level, and that success or failure in any one trial is of small importance. Because these conditions do not meet the explicit assumptions of Atkinson's theory, a new approach is required to explain the reported motive-related differences in preference for moderate probability of success in multiple trial tasks. (Author)

# PROBABILITY OF SUCCESS IN MULTIPLE TRIAL TASKS: IMPLICATIONS FOR ATKINSON'S THEORY OF MOTIVATION AND RISK TAKING BEHAVIOR

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Probability in Multiple Trial Tasks

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## Footnotes

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# PROBABILITY OF SUCCESS IN MULTIPLE TRIAL TASKS: IMPLICATIONS FOR ATKINSON'S THEORY OF MOTIVATION AND RISK TAKING BEHAVIOR

July 11, 1974

In a recent test of Atkinson's (1957) theory of motivation and risk taking behavior (Hamilton, 1974), it was noted that given 10 throws at a variable distance ringtoss, Ss did not appear to aspire to a perfect score of 10. It appeared that contrary to an assumption of the study, a S considered himself successful if he exceeded his expected score; and a revision of Atkinson's model was proposed in that paper in order to explain this behavior. However, if subjects playing a ringtoss in fact perceive success in terms of exceeding expected score, the theoretical implications are more complex than was suggested in the earlier study. The present paper pursues these implications in detail. It is comprised of (a) a discussion of the assumptions that Atkinson's theory makes about the nature of subjective probability of success and its relationship to the concept, risk; (b) a report of experimental research designed to determine empirically how people operationalize success in a multiple trial task; and (c) a proposed extension of Atkinson's general theory to a class of aspiration tasks for which the concept, risk, does not seem to be appropriate.

## Subjective Probability of Success in Atkinson's Model

In Atkinson's theory of risk taking behavior, risk is defined as the product of a person's subjective probabilities of success and of failure in the task (Ps and Pf, respectively); and the incentive values he associates with success and with failure (Is and If, respectively). In the theoretical model, three assumptions are made: (a) Subjective probability of success

and subjective probability of failure are complementary; hence Pf = 1-Ps. (b) The harder the task, the greater the incentive value of success; hence Is = 1-Ps. (c) The easier the task, the greater the negative incentive value of failure; hence If = -Ps. Thus the nonbasic variable, risk, is completely specified in terms of the single basic variable, subjective probability of success in the task (Ps).

Although Atkinson was concerned primarily with motives, Ps is the pivotal variable in the model. The model, which is discussed in detail in Atkinson (1957; revised in Atkinson, 1964), is summarized briefly below. In addition to the probability and incentive components, it includes motive to seek success (Ms), motive to avoid failure (Mf), tendency to seek success (Ts), tendency to avoid failure (Tf), and resultant or net tendency (Tr).

$$Ts = Ms \times Ps \times (1-Ps) = Ms \times (Ps - Ps^2), \quad [1]$$

$$Tf = Mf \times (1-Ps) \times (-Ps) = -Mf \times (Ps - Ps^2), \quad [2]$$

$$Tr = Ts + Tf = (Ms - Mf) \times (Ps - Ps^2). \quad [3]$$

These equations are designed so that each term except motive is a function of Ps, and so that the first derivative is zero when Ps = .5. Thus, both the approach and the avoidance tendencies are maximized when Ps = .5. In behavioral terms, the model states that when faced with a choice among aspiration tasks in which the subjective probabilities of success range from zero to one, people with Ms > Mf tend to choose tasks with moderate Pss, where there is both a reasonable challenge and a reasonable chance of success; whereas those with Mf > Ms tend to choose tasks with extreme Pss where success is more certain or else failure easier to rationalize.

The earlier study (Hamilton, 1974 ) tested this model against accurate and reliable estimates of Ps. These estimates were generated by the same procedure used in the present study and described in detail below.

In this procedure, each S is given extensive practice at a variable distance ringtoss often used in aspiration research. On the basis of the practice, it is possible to estimate accurately a S's probability of scoring a ringer on any single throw at any distance from the peg. This procedure made it possible to test Atkinson's theory precisely against probability estimates that were known and acknowledged by both the S and the E. It was found that Ss with Ms>Mf preferred an average Ps of .4 significantly more than did Ss with Mf>Ms--a result interpreted as being close to the prediction of the model.

The confusion centers around the fact that the critical Ps, .4, was the probability of scoring a ringer on any single throw. If, as suggested above, the subjects considered themselves successful if they exceeded their expected scores, than .4 was not in fact the probability of success. This can be seen clearly in Figure 1, which plots the probability of scoring a ringer on any single throw (Ps1) against the probability of exceeding the expected score in 10 throws from the same distance (Ps10). Clearly the two are not the same. Consider the person who stands where his Ps1 is .9. If he throws a single ring, his probability of success is simply .9. However, if he throws a set of 10 rings, his probability of exceeding his expected score of nine is only .36.

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Insert Figure 1 about here

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If people perceive success in the 10-trial ringtoss as exceeding expected score, then the probability of success is equal to Ps10, not Ps1; and inasmuch as Atkinson's model is built around the concept probability of success, this would imply that the behavior of subjects in the earlier

study should have been analyzed with respect to Ps10, not Ps1. However, this analysis yielded confusing results. This distribution of Ps10 shown in Figure 1 has a very small range--.26 to .38--and therefore, even if people were able to perceive the small differences in Ps10, they could not demonstrate pronounced approach or avoidance of any value of Ps10. Furthermore, although Ps1 always becomes smaller as distance from the peg increases, the same is not true of Ps10. The probability of exceeding the expected score actually increases as distance from the peg increases up to the distance associated with a Ps1 of .7. Finally, the theoretically critical value of Ps, .5, is not in the range of Ps10. Anyone trying to approach this value would have to throw the rings from the distance at which Ps1 equals .7, where Ps10 is closest to .5. Clearly, the reported critical Ps1 of .4 cannot easily be interpreted as consistent with Atkinson's theory if success indeed requires exceeding the expected score.

If it can be demonstrated that people see success in a 10-trial ring-toss as exceeding expected score, then it could be argued reasonably that the true critical probability of success in the earlier study was not .4 as originally reported, but the Ps10 associated with a Ps1 of .4. This raises two questions: (a) Can Atkinson's model account for the observed motivation-related differences in tendency to approach a Ps1 of .4? And (b) if not, how can these results be explained?

## Determining Success in a Multiple Trial Task

Experimental research was conducted to validate the casual observation in the earlier study: that success in a 10-trial ringross requires exceeding the expected score, and that performance equal to expected score

is less than successful. The study was based on both behavior and self report attitude measures. Subjects' attitudes toward performance levels were measured both before and after they played at the ringtoss. This allowed investigation of the extent to which self report before the task reflected aspiration or optimism, and conversely, the extent to which evaluation after the fact was self serving.

At best, however, self reports are subject to many uncontrollable biases, and therefore were used here only as supplements to a behavioral measure. Sears (1940) developed the concept of the normal adaptive response, which states simply that success usually is followed by a slight increase in level of aspiration. In the present study it was assumed that if a slight increase in aspiration was observed, then success had occurred. The general hypothesis, then, was tested on the basis of self report before performance, self report after performance, and behavior after performance.

Note that the specific hypotheses below are phrased in terms of well known affective and behavioral correlates of successful performance. Their purpose is not to test again these relationships. On the contrary, it is assumed that the relationships indeed are valid. The key assumption is that if the correlates of success are observed in connection with exceeding expected score, then it may be inferred that exceeding the expected score is a valid operational definition of success.

Hypothesis 1. When Psl is known and multiple trials are allowed, and when scores are rated before performance, the expected score is given a rating of less than "good."

Hypothesis 2. When Psl is known and multiple trials are allowed, and when performance is evaluated after the fact, evaluation is positively

related to deviation from expected performance, and performance equal to the expected level is given an evaluation of less than good.

Hypothesis 3. After exceeding the expected score, a person shows a small increase in level of aspiration; and this response is not characteristic of a person whose performance was equal to or less than the expected score.

## Method

### Measures

Prior Rating Scale. This instrument consists of a form on which the numbers 0 through 10 are arranged in a column with a blank line next to each number. Before throwing from his chosen distance, the S is asked to label each possible score, good, satisfactory, or bad, in light of his distance from the peg and his expected score.

Performance Evaluation Scale. This instrument consists of a continuous line labeled to reflect the dimension quality of performance. The midpoint is labeled "satisfactory or adequate," with the line on one side representing increasing degrees of good, and the line on the other side, increasing degrees of bad. The words good and bad are placed below the appropriate line segments half way between the midpoint and the end.

Change in Aspiration. From Figure 1 it can be seen that a S who has exceeded by one the expected score from his chosen distance may choose between two likely ways in which to lower his Ps10 and thereby to increase his level of aspiration: he may remain at the same distance and try to exceed not only the expected score but also the higher score he has just achieved; or he may move to a greater distance (a lower Ps1) and try to exceed the expected score from that distance. Of the two, moving to a lower Ps1 is more consistent with the concept of the normal adaptive response than is

attempting to better a score that already exceeds the expected score. Figure 1 shows that unless the initial Psl was greater than .7--an uncommon occurance--moving to a lower Psl results in a slightly lower Psl0, whereas staying in the same place and trying to exceed the expected score by two or more results in a very large decrease in Psl0--never less than 50%. For this reason, it is concluded that an increase in aspiration will be manifest in the choice of a lower Psl.

An important assumption in this argument is that a S's perception of his ability is not significantly influenced by the outcome of his first experimental set of 10 throws--that is, that his distribution of Psl remains constant. This assumption is justified because the procedure by which a S's probability distribution is generated, which is described in detail below, requires the S to take 140 practice throws. The performance at each distance influences the Psl assigned to every distance, with the result that any chosen Psl is in effect based on 140 throws. If, as postulated by Atkinson (1964), a person considers his Ps in a task to be equal to the number of successful trials divided by the total number of trials, the 141st through 150th throws would be expected to have only a slight effect on the resulting Psl, and the initial probability distribution would be accurate even after these throws.

Ms and Mf. Inasmuch as the focus of this study is the measurement and interpretation of the probability and incentive components of Atkinson's model, measures of the motive components were not taken.

## Subjects

The experimental Ss were undergraduate business students. Of the 118 who volunteered for the study, eight were disqualified either because of experimenter

error or because of very low ability at the experimental task. Of the remaining 110, all but a few were sophomores. Eighty-two were men, and 28 were women. Fifty-seven were assigned randomly to test the hypotheses of the present study.

Procedure

Calibration: a full discussion of the theoretical and practical considerations that underlie the calibration procedure can be found in Hamilton (1974). It was the first part of the experimental procedure, regardless of the treatment to which a subject was assigned. Each subject met individually with an E, and then was shown the ringtoss that had been described to him when he was recruited. The equipment consisted of a peg 11 3/4 inches high and 1 3/4 inches in diameter; 10 rings, each 10 inches in diameter; and a mat marked off in 1-foot intervals up to 18 feet from the peg. As in earlier studies, the S was given 10 rings and told to see how well he could do at getting them onto the peg. He was told that he might stand anywhere on the mat that he wished and that he might change distances as he saw fit. He was advised further that the E was going to record where he stood on each throw and whether or not he scored a ringer.

After completing 10 throws, the S was told that for most people it was desirable to take some structured practice at the ringtoss. It was pointed out to him that varying degrees of familiarity with the game, the time of day, individual differences in reactions to unfamiliar tasks, and many other factors could cause the results of the first few throws to be misleading. The structured practice consisted of 10 consecutive throws from each of 13 foot markers, with the distances (in feet) from the peg ordered as follows: 4, 12, 9, 14, 6, 11, 8, 16, 5, 18, 7, 10, 3.

The E constructed a graph whose abscissa was distance from the peg and whose ordinate was number of ringers in 10 throws. He noted with a mark on the graph the number of ringers scored at each distance, and after the practice was finished, he visually smoothed a curve through the dots. He then showed the curve to the S, explaining what it was, and demonstrating how it averaged unusually high or low scores. In most cases the obtained scores described a fairly smooth curve and little averaging was necessary.

Having explained the curve, the E took 10 blocks, each marked with an integer from 1 to 10 inclusive, and explained that he was going to "translate" the curve onto the mat in order to make it more concrete. He then placed each block onto the right edge of the mat at the distance from which, on the basis of the smoothed curve, the S had scored 10, 9, 8, etc. ringers in 10 throws. The S then was asked if he thought the blocks accurately represented his performance, and if he had any reason to think he would perform differently in the immediate future. It was stressed that the S was to give the question serious consideration. Most Ss stated that the blocks were accurate as placed. Those few who were unsure took further practice. In some cases the blocks were adjusted; in others they were not. This completed the calibration process. The subsequent procedure depended on the treatment to which the S was assigned.

Tests of Hypotheses: After calibration, each S was assigned at random to one of four treatments, arranged in a 2 X 2 design. The treatments differed in the use or nonuse of the prior rating form and the performance evaluation scale. Ss completed the former only, the latter only, both, or neither. The design was intended not to test the hypothesis, but to reveal if the mere act of rating scores or of evaluating performance has any effect on subsequent self report or behavior.

Fifteen Ss completed both forms. Each was given 10 rings and asked to select a distance from which he would throw all 10. After choosing the distance, but before throwing the rings, he was asked to complete the prior rating form for all possible scores. After explaining the form, the E turned his back and moved a short distance away in an attempt not to bias the ratings. Thereafter he did not look at the form or call further attention to it. After completing the form, the S threw the 10 rings. Then, before retrieving the rings, the E gave him the performance evaluation scale and instructed him to evaluate his performance on that set of throws. Again, after explaining the scale, he moved away from the S. After evaluation, the S again was instructed to select any single distance he wished and again to see how many ringers he could score in 10 throws.

Ss in the other treatments followed the same procedure, except that either the prior rating scale was omitted (n=14); or the performance evaluation scale was omitted (n=15); or both were omitted (n=13). Those for whom the performance evaluation form was "omitted" in fact completed the form, but for the second set of throws instead of the first, and therefore after all other observations had been taken.

## Results

### Manipulation Checks

The validity of the estimates of Psl requires that these estimates not be confounded with ability at the task, and that they represent a short term plateau in skill. Checks similar to those used in earlier research (Hamilton, 1974) were made, and all were satisfactory. There was no relationship between ability on the ringtoss and initial choice of Psl. As expected, there was significant improvement from precalibration throws to postcalibration

throws. Also as expected, Ss did not score differently from expectation on either set of postcalibration throws, nor did performance differ significantly from one set to the other.

There was no indication that the act of completing either the prior rating scale or the performance evaluation form had any effect on subsequent self report or behavior. Therefore results are presented for all Ss regardless of differences in the administration of the self report measures.

Tests of Hypotheses

Hypothesis 1: Hypothesis 1 was supported. Of the 28 Ss who correctly completed the prior rating form, only three gave the expected score a rating of good. The normal approximation to the binomial test, corrected for continuity, shows clearly that the three Ss were in the minority ($z=3.96$, $p < .00005$).

Hypothesis 2: Because the "satisfactory" point on the performance evaluation scale was always at the midpoint of the scale, but expected score was allowed to vary from 1 to 10, it was necessary to hold expected score constant when calculating the correlation between performance evaluation and the amount by which the actual score exceeded the expected score. The first order partial correlation coefficient was significant ($r=.78$, $d.f.=54$, $p<.001$). As predicted, evaluation was highly correlated to the amount by which actual performance exceeded expected performance.

Because performance was allowed to vary naturally, an evaluation of a score equal to the expected number of ringers was available for only 22 Ss. Of these, six evaluated performance equal to the expected score as good, and 16 as less than good. The exact binomial test shows that this difference is significant in the predicted direction ($p<.05$). As predicted, actual performance had to exceed expected performance in order to be evaluated as good.

Hypothesis 3: Table 1 shows clearly that after exceeding the expected score, Ss tended to move to a greater distance and lower expected score; whereas after either equaling or scoring less than the expected score, they showed no systematic behavior in subsequent choice of Psl ($\chi^2$=5.25, $p<.05$). It should be noted that had the cells been combined so that those achieving the expected score were grouped with those exceeding that score, there would have been no significant difference in behavior contingent on performance. This lends support to the inference that merely achieving the expected level of performance is not success, whereas exceeding that level of performance is success.

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Insert Table 1 about here

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## Discussion

The uniform support of the hypotheses suggests that in a 10-trial ringtoss, success indeed requires exceeding the expected score. As pointed out earlier in the paper, this implies that Psl0 is a more appropriate measure of the probability of success in the 10-trial ringtoss than is Psl, and therefore that the problems encountered in trying to reinterpret the results of the earlier study in terms of Psl0 are real ones. The task now is to determine what the reported Psl of .4 (Hamilton, 1974) represents, if not probability of success, and why Atkinson's model was able to predict behavior in that study.

### Reinterpretation of Psl

Some insight into the meaning of Psl under the conditions of the ringtoss can be gained from postexperimental interviews incidental to this and other research. Consider the S who knows his Psl at any distance, and who chooses to throw a single ring from the distance at which his Psl is .2. Although the throw has a .8 chance of missing, nonetheless there is some indication that

a miss can be perceived by the S as less than a complete failure. It can be well coordinated, a near miss, a leaner, etc. Over the course of many throws, these characteristics are reflected in the score; that is, good luck and bad luck on any single throw play a smaller part. However, on a single throw, neither a score of one nor a score of zero accurately reflects a S's long term expected performance except from extremely short or extremely long distances. If a person realized this it would not be accurate to interpret his behavior as indicating any preference for a .2 probability of success in one throw. It might be more appropriate to interpret his choice as manifesting preference for a long term performance level; that is a long term expected success rate of 20%. This interpretation of Psl is reasonable for any aspiration task in which the number of trails is potentially unlimited and for which no exogenous contingencies are present.

One Trial Tasks vs. Multiple Trial Tasks

The concept of Psl as representing a long term performance level rather than a probability of success suggests that the ringtoss and similar tasks are fundamentally different from the type of task upon which Atkinson's model is based, the difference being the relevance of the concept, risk. Atkinson's model implicitly assumes that the only possible outcomes to the aspiration task are success and failure, and that the difference between the two is clearcut. This would apply, for instance, in the case of a person who aspires to win a given election. Ultimately this objective either will be reached or not, and to the extent that the person has articulated it to himself or to others, it is fair to say that he has taken a risk. In a situation such as this, the assumptions underlying the probability and incentive components of Atkinson's model of risk taking behavior seem to be met.

The conditions that obtain during tasks such as the ringtoss are very different. If a task can be repeated potentially without limit, then as long as no exogenous contingencies are imposed there is no obvious criterion by which to determine success or failure. The expected long term performance level is merely a predictor of future performance level, and it does not seem reasonable that risk taking behavior would influence one's independent choice of expected performance level. Only by limiting the number of trials and introducing an exogenous contingency such as a prize, peer approval, feelings of superiority or inferiority--that is, by defining the incentive components of the model as something other than the intrinsic incentives associated with success and failure--can success and failure be given sufficient meaning to justify explaining choice of Ps in terms of risk taking behavior. However, Atkinson's theory is expressly concerned with behavior in aspiration tasks in which the incentives are determined by Ps and by nothing else. It is not intended to explain or predict motive-related differences in response to selected exogenous contingencies, and so such contingencies cannot be taken as a legitimate basis for inferring risk.

It is likely that the distinction between the risk implications of single trial tasks and those of multiple trial tasks has not been made before this for two reasons. First, the probability of success in a single trial is mathematically identical to expected long term performance level save for the number of trials. Second, the observed behavior was successfully predicted on the basis of Atkinson's model of risk taking behavior. In earlier studies when Ps was operationalized by rough inference, authoritative statement, or self report, the meaning of the concept was sufficiently hazy to preclude making precise distinctions such as the one between Ps10 and Ps1. Moreover, because the results of those studies were consistent with the

predictions of the theory, there was little incentive to search out such distinctions. (See Hamilton ( 1974) for a discussion of earlier attempts to measure Ps.) Until the calibration method of the present study was developed and used to test the theoretical model, there was no reason for questioning the relationship between the theoretical model and the empirical evidence. However, it is clear from the argument presented in this paper that Ps1 cannot be interpreted as probability of success when multiple trials are allowed; and no one would argue that successful prediction of behavior necessarily implies understanding or explanation of that behavior. Rather, it appears that although the ringtoss and similar aspiration tasks do not satisfy the assumptions of Atkinson's model, nonetheless the model accurately predicts motivation-related behavior on these tasks.

A Paradox in Testing Atkinson's Model

It is intriguing to note an apparent paradox built into Atkinson's model. Certainly in order to test the model precisely it is essential to have estimates of Ps that are valid and reliable and that are known and acknowledged by both the S and the E. The calibration procedure of the present study accomplishes this, and has clear advantages over others that have been employed. Specific methods and their drawbacks--e.g.: Littig (1966), Atkinson & Litwin (1960), Litwin (1966)--are discussed elsewhere (Hamilton, (1974). However, as discussed at length above, if a task is of the variety that lends itself to the generation of estimates of Ps, it is not of the variety to which Atkinson's model is relevant. Therefore, the model is by its very nature untestable. Its acceptance or rejection must be predicated on only rough estimates of Ps, and interpretation of the empirical evidence must reflect the specific estimating method used.

## Conclusions

Two questions were posed above: The first was, can Atkinson's theoretical model reasonably explain behavior when Psl is not equal to probability of success in the task? The answer appears to be no. Although observed behavior was predicted by Atkinson's model, there seems to be no way that it reasonably can be explained or understood in terms of that model of risk taking behavior.

The second question was, if Psl is not the same as probability of success in the task, then why did the motive related differences occur in the earlier study (Hamilton, 1974)? The answer appears to be that the results of that study reflect a behavioral correlate of motivation not reported before: namely, that people with Ms>Mf prefer moderate levels of long term performance more than do people with Mf>Ms.

These conclusions represent a significant departure from those of earlier studies that explain every manifestation of motive-related differences in preference for moderate Pss in terms of Atkinson's model of risk taking behavior; and they suggest that understanding of behavior in multiple trial tasks must be based on some other theory. Clearly it would be possible to leave the model unchanged and merely specify that Ps stands for expected long term performance level rather than subjective probability of success in the task. However, although this would suffice mathematically, it would result in meaningless incentive components, for the justification for setting Is equal to 1-Ps and If equal to -Ps is that Ps stands for probability of success in the task. Moreover, the explicit tie between the model and aspiration theory (Lewin, Dembo, Festinger & Sears, 1944) also depends on this definition of Ps.

Inasmuch as single trial tasks and multiple trial tasks fundamentally differ with respect to risk cues, it seems that there is a need for a

theory that would explain observed behavior in the latter type of task-- a theory that would explain why people with Ms>Mf should show a stronger preference for moderate levels of performance than should people with Mf>Ms, even though there are no risk cues present. It is suggested that theory construction and empirical research in this vein could add significantly to our understanding of how motives influence behavior.

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TABLE 1

Change in Psl Contingent

upon Performance (n=57)

| Change in Psl | Actual Score vs. Expected | | |
|---|---|---|---|
| | <Expected | =Expected | >Expected |
| Increase | 10 | 1 | 3 |
| None | 6 | 2 | 2 |
| Decrease | 12 | 3 | 18 |

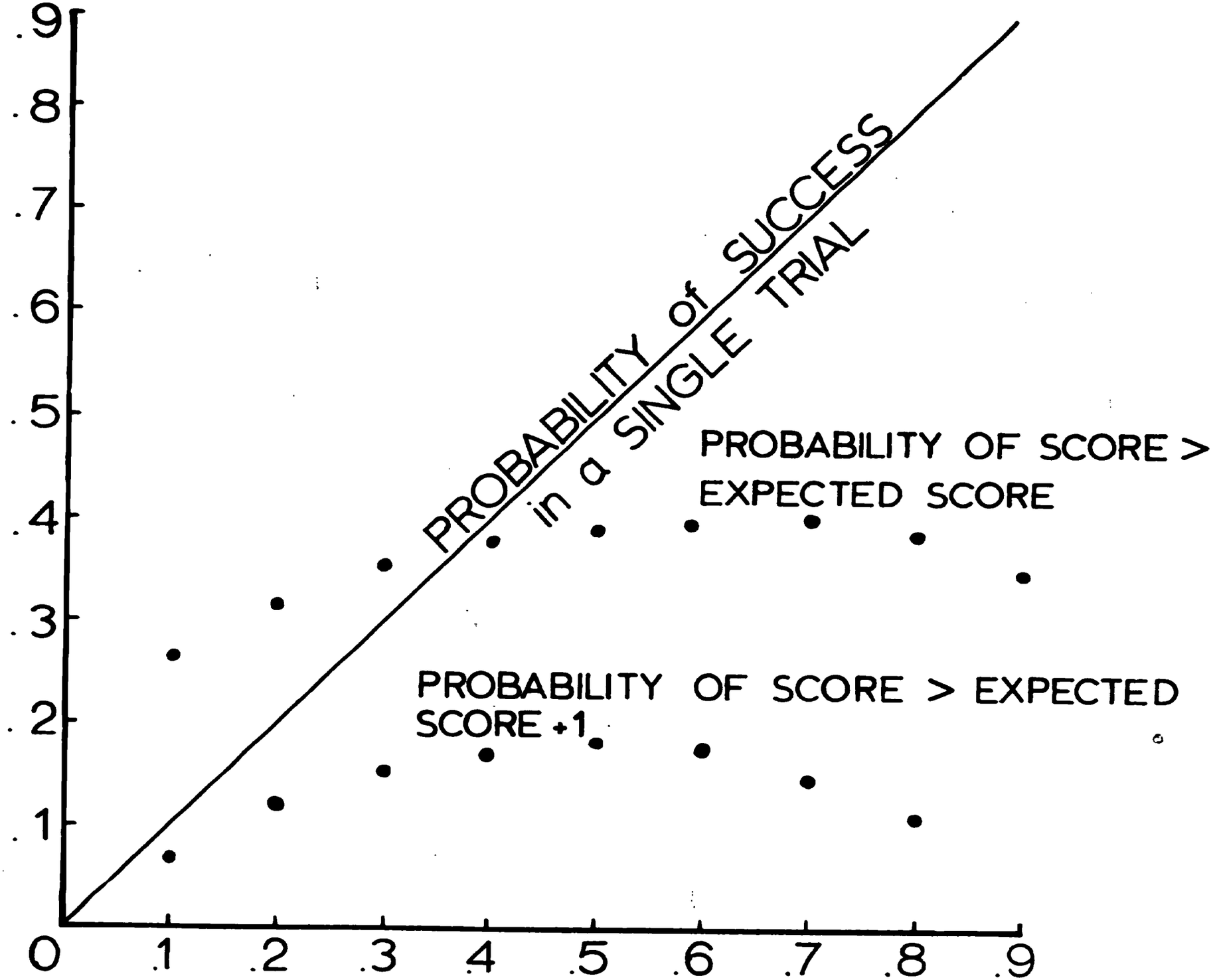
$\chi^2 = 5.25^*$, d.f.=1

Note.--Heavy lines denote cells combined for test.

* $p < .05$

## Figure Captions

Figure 1. Probability of success in one throw vs. probability of success in 10 throws.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PROBABILITY of SUCCESS in a SINGLE TRIAL
PROBABILITY OF SCORE > EXPECTED SCORE
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