May 30, 1938

Dear Jeffreys,

Thanks for your letter of May 19th on Kendall's application. I am glad you agree with me on broad lines.

Reconsidering the matter I think part of the trouble must be that Kendall does not understand what one uses randomisation for, at least in experimentation. It is, as it seems to me, a tribute to our ignorance of the nature of the errors to which our results will be liable. Thus, if I want to test the capacity of the human race for telepathically perceiving a playing card, I might choose the Queen of Diamonds, and get thousands of radio listeners to send in guesses. I should then find that considerably more than one in 52 guessed the card right; also that of those guessing wrong more than half got the colour right, and probably a number of such favourable indications would be obtained. On the other hand, if I choo choose the 8 of Spades, I should expect to get just the opposite result.

Experimentally this sort of thing arises because we are in the habit of making tacit hypotheses, e.g.

"Good guesses are at random except for a possible telepathic influence". But, in reality it appears that Red cards are always guessed more frequently than Black.

For years agricultural experimenters made the similar unconscious hypothesis, "Errors on different plots are distributed independently in the normal curve". Actually the normal curve is good enough, but the errors are very far from independent, consequently any systematic arrangement may contain factors in common with the actual pattern of natural fertility . This difficulty is so fundamental that one has to consider the problem in an extreme form. Let the Devil choose the yields of the plots to his liking; his only restriction is that he may not change his mind after I have chosen where the different treatments are to fall. If, now, I assign treatments to plots on any system which allows any two plots which may be treated alike an equal chance of being treated differently , in the different ways in which this is possible, then it can be shown that both the experiment is unbiassed by the Devil's machinations, and that my test of significance is valid.

Things are not really so bad as in this game.

We know nothing in detail about the errors, but experience does indicate certain components which are very often important, and such components one does not leave to chance but completely eliminates. Thus, if one had equal ~~errors~~ areas in two fields, one might legimately assign pairs of plots, one from each field, and toss up between treatments A and B; ~~thus~~ then it would be annoying if chance (or the sequence of random numbers) put 7 A's running in the same field, which is the sort of thing liable to happen. If the same sequence of numbers were used for adjacent plots, its locally systematic character would not matter, a run of alternate treatments might be quite good. Though, again, if ~~one~~ we suspected alteration in field fertility, such as is known to ~~vary~~ occur sometimes, or even a steady gradient, one might prefer to randomise entire sandwiches A B B A, or B A A B by a single act of randomisation.

I think you hit the nail on the head in saying that a sequence can only be random once. Hence one must insist on a fresh ~~subdivision~~ randomisation each time when a set of identical experiments is laid down. For the same reason it is desirable that different centres should, as is already found convenient, each use their own tables for those purposes for which tables save time.

In principle I agree with you about the Latin square. Rows and Columns usually take out a useful lot of error, but I should not claim that the elimination of the same number of degrees of freedom, 12 in a 7 x 7 square, could not take out more. If, however, you impose the limitation that the ~~completely~~ components eliminated shall be orthogonal to those used for treatments, the combinatorial problem becomes greatly involved. I should, however, have no objection in theory to the claim that better arrangements can be found. One fact which makes the Latin Square work well in practice is that on any given field agricultural operations, at least for centuries, have followed one of ~~three~~ two directions, which are usually those of the rows and columns; consequently streaks of fertility, ~~and~~ weed infestation, etc., do, in fact, occur predominantly in these two directions. Streaks in other directions introduce bias in systematic squares, but validly estimated errors in random squares.

Yours sincerely,