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David J. Finney

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DISCUSSION ET COMMENTAIRES

La planification des expériences : choix des traitements et dispositif expérimental

David J. FINNEY [1]

One expects that anything from the pen of Pierre Dagnelie will comprise sound theory allied with good sense in the use of statistical science as an aid to the quantitative understanding of practical problems. This paper is no exception.

Dagnelie believes that potential benefits from good experimental design are being lost. Too often, the designing of an experiment is regarded as being primarily the choice of treatments and their logical interrelations (as in a multifactorial structure). Important though this is, it should not be followed by inadequate attention to decisions on replication, randomization, and the 'local control' of variation by systems of blocks.

I read with alarm the author's repeated statements that blocking to exploit the combinatoric aspects of design is often neglected. My own career has spanned the period when the need to respond to newly recognized experimental objectives gave so many statisticians the delight of constructing new variants of incomplete blocks, confounding, and like devices. During my school days, combinatorics as a branch of mathematics were largely dismissed as unworthy of the attention of serious mathematicians. During the last seventy years, this attitude has totally changed, in no small part because statisticians developed a very practical interest in new combinatorial problems and showed them to be a fertile source for deep mathematical research.

Most experimenters, whether in a biological science or in industrial technology, are subject to constraints on resources. These will commonly be major determinants of the possible replication. Dagnelie warns that under-replication may imperil the usefulness of results because it can lead to imprecision in the estimation of an error variance. By contrast, in special circumstances connected with large trials for selecting new crop varieties, I have identified a possibility that random discarding of some candidate varieties can aid the expected rate of yield improvement.

The constraints to which a programme of experimentation is subject may be expressed in terms of limits :

(A) On the area of land available for an experimental crop,

1. 13 Oswald Court, South Oswald Road, Edinburgh EH9 2HY, U.K. e-mail : djf. freeuk.com

(B) On the amount of a new material (such as a new drug) available for clinical trial,

(C) On the availability of skilled manpower for performing laborious and possibly novel operations,

(D) On laboratory facilities for chemical or other analyses of produce,

(E) On the time that can be spared before results must be used as a basis for a policy decision,

(F) Or in other ways – but not, one hopes today, – on availability of professional statistical or computational help for the interpretation of results!

Consequently, the question that an experimenter wishes to ask his consultant statistician may be : "How do I design the best experiment that conforms with my constraints?" Here, as so often, the word 'best' requires clarification. It may need to mean :

(a) With maximum precision on the estimate of a single parameter;

(b) With maximum precision on an expression defined as a function of all the parameters in the current model. Examples are :

  (b1) A difference of population means for two treatments

  (b2) A complex contrast appropriate to one of the components of 'Treatments' in the classical analysis of an experiment with factorial treatment structure

  (b3) Abscissae for the maximum of a response curve or surface, as discussed illuminatingly by Dagnelie in his Section 7

  (b4) An expression such as that for the estimating the logarithm of relative potency in classical experiments for the biological assay of drugs by comparison of linear regression equations;

  (b5) Doubtless others;

(c) With maximum probability of claiming statistical significance for a specified true difference of means;

(d) With maximum quantity of statistical information on a nominated set of parameters;

(e) Or others that may emerge in discussion between a scientist or technologist and a consultant statistician when the issue of the purpose of an experiment is explored in depth.

Of all the contributions that R. A. Fisher made to statistical science, possibly none was more important than his introduction of randomization as an integral part of the planning of experiments and investigations by planned sampling. Logically essential to rigour in testing statistical significance, only strict randomness in the allocation of treatments to experimental units can eliminate the biases that are inevitable if even the most honest of experimenters has any subjective influence on this allocation.

Dagnelie's experience has evidently brought to his notice the failure of experimenters to replicate adequately. He has devised an ingenious method of presenting the consequences of different levels of replication. A little unfortunately, this possibly gives excessive emphasis to significance tests. In my view, few experiments are undertaken with the primary aim of providing a classical significance test as in (c) above. Usually the objective is to assign, with probabilistically controlled confidence, limits to the value of a quantity that may be a simple parameter or a function of the several parameters in a model. For example, if interest attaches to a parameter that represents a response to treatment, it will be rare for critical concern to lie with whether a lower confidence limit is 0.0001 or -0.001. About forty years ago [Finney, 1959, 1962, 1963], I approached the choice of experimental replication by consideration of the yield of Fisher information. Although this might give a more comprehensive presentation of the choices available, my ideas have never been further developed.

RÉFÉRENCES BIBLIOGRAPHIQUES

FINNEY D. J. [1959]. The economic efficiency of experimentation. *Publications of the Mathematical Institute of the Hungarian Academy of Sciences*, 4, 203-224.

FINNEY D. J. [1962]. L'esperienza statistica e il piano d'indagine. *La Scuola in Azione*, n°19, 158-180.

FINNEY D. J. [1963]. Statistical experience and the design of investigations. Colloques Internationaux du Centre National de la Recherche Scientifique, n°110, *Le Plan d'Experiences.*