Planning Experiments

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In this note, I outline some steps you can follow in the design of experiment. We will revisit later when we cover in depth the various designs and statistical analysis.

A Checklist for Planning Experiments

1. Define the objectives of the experiment.
2. Identify all sources of variation, including
   - treatment factors and their levels;
   - experiment units; Subjects receiving treatment
   - blocking factors, noise factors and covariates.
3. Choose a rule for assigning experimental units to the treatments. Ex) Randomization
4. Specify the measurements to be made, the experimental procedure, and the anticipated difficulties.
5. Run a pilot experiment.
   Small scale

A Checklist for Planning Experiments

6. Specify a statistical model.
7. Outline the statistical analysis – Note this is the planning stage so the outline of analysis is sufficient. The statistical analysis will be performed after the experiment is completed and data are collected.
8. Calculate the number of observations needed to reach the desired statistical power.
9. Review the above decisions. Revise if necessary.

A Real Experiment — Cotton-Spinning Experiment (Robert Peake, 1953, Journal of Applied Statistics)

1. Define the objective of the experiment

- to investigate how the degrees of twist (measured in turns per inch) affected the breakage rate of the roving, and
- to compare the ordinary flyer with the newly devised special flyer. A flyer is the rotary guide that produces the twist.

A Real Experiment

2. Identifying all sources of variation.

- Treatment factors and their levels.

  There are two treatment factors: type of flyer (ordinary and special, coded as 1 and 2), and degrees of twist. Based on a pilot study, 4 unequally spaced levels were selected for the degree of twist, 1.63, 1.69, 1.78, 1.90. Coding these levels as 1, 2, 3, and 4. The 8 treatment combinations are 11, 12, 13, 14, 21, 22, 23, 24 as shown in the following table. From the pilot experiment, treatments 11 and 24 resulted in higher breakage rates. They were not used in the formal experiment. Hence a total of 6 treatments were used.

	Twist			
	1.63	1.69	1.78	1.90
Flyer: Ordinary	11	12	13	14
Flyer: Special	21	22	23	24

A Real Experiment

- Experimental units. A unit is the thread on the set of full bobbins in a machine on a given day.
- Blocking factors: Apart from the treatment factors, other sources of variation: the different machines, the different operators. One blocking factor was used, i.e., the combination of machine and operator.

3. Choose a rule to assign the experimental units to the treatments. A randomized complete block design was selected. The 6 experimental units within each block were randomly assigned to the 6 treatments. We will talk in more details about such designs.

A Real Experiment

4. Specify the measurements to be made, the experimental procedure, and the anticipated difficulties

The response variable is the number of breaks per 100 pounds of material. Part of the job of the machine operator was mending every break in the roving so it was easy for the operator to keep a record of every break that occurred. The experiment was to take place during the normal routine. The major difficulties include the length of time involved for each observation, the loss of production time caused by changing the flyers, and the fact that it was not known in advance how many machines would be available for the experiment.

A Real Experiment

5. Run a pilot experiment.
6. Specify the model

A particular design is usually associated with some statistical models. We will cover the statistical models appropriate for randomized complete block designs.

A Real Experiment

7. Outline the analysis

The analysis was planned to compare differences in the breakage rates caused by the 6 treatments. Further, the trend in breakage rates as the degree of twist was increased was of interest for each flyer separately.

8. Calculate that number of observations that need to be taken.

In order to detect a true difference in breakage rates of at least 2 breaks per 100 pounds with high probability, 56 blocks were needed. The calculation of the required number of blocks will be discussed later.

A Real Experiment

9. Review the above decisions. Revise, if necessary.

Since each block could take about a week to observe, it was decided that 56 blocks was impossible. The experimenters decided to analysis the data after 13 blocks had been run.