Factorial Design

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A factorial design is often used by scientists wishing to understand the effect of two or more independent variables upon a single dependent variable.

Traditional research methods generally study the effect of one variable at a time, because it is statistically easier to manipulate. However, in many cases, two factors may be interdependent, and it is impractical or false to attempt to analyze them in the traditional way.

Social researchers often use factorial designs to assess the effects of educational methods, whilst taking into account the influence of socio-economic factors and background.

Agricultural science, with a need for field-testing, often uses factorial designs to test the effect of variables on crops. In such large-scale studies, it is difficult and impractical to isolate and test each variable individually.

Factorial experiments allow subtle manipulations of a larger number of interdependent variables. Whilst the method has limitations, it is a useful method for streamlining research and letting powerful statistical methods highlight any correlations.

The Basics

Imagine an aquaculture research group attempting to test the effects of food additives upon

the growth rate of trout.

A traditional experiment [1] would involve randomly selecting different tanks of fish and feeding them varying levels of the additive contained within the feed, for example none or 10%.

However, as any fish farmer knows, the density of stocking is also crucial to fish growth; if there are not enough fish in a tank, then the wasted capacity costs money. If the density is too high, then the fish grow at a slower rate.

Rather than the traditional experiment, the researchers could use a factorial design and co-ordinate the additive trial with different stocking densities, perhaps choosing four groups. The factorial experiment then needs 4 x 2, or eight treatments.

The traditional rules of the scientific method [2] are still in force, so statistics [3] require that every experiment be conducted in triplicate.

This means 24 separate treatment tanks. Of course, the researchers could also test, for example, 4 levels of concentration for the additive, and this would give 4 x 4 or 16 tanks, meaning 48 tanks in total.

Each factor is an independent variable, whilst the level is the subdivision of a factor. Assuming that we are designing an experiment [4] with two factors, a 2 x 2 would mean two levels for each, whereas a 2 x 4 would mean two subdivisions for one factor and four for the other. It is possible to test more than two factors, but this becomes unwieldy very quickly.

In the fish farm example, imagine adding another factor, temperature, with four levels into the mix. It would then be 4 x 4 x 4, or 64 runs. In triplicate, this would be 192 tanks, a huge undertaking.

There are a few other methods, such as fractional factorial designs, to reduce this, but they are not always statistically valid. This lies firmly in the realm of advanced statistics and is a long, complicated and arduous undertaking.

The Pros and Cons of Factorial Design

Factorial designs are extremely useful to psychologists and field scientists as a preliminary study, allowing them to judge whether there is a link between variables, whilst reducing the possibility of experimental error [5] and confounding variables [6].

The factorial design, as well as simplifying the process and making research cheaper, allows many levels of analysis. As well as highlighting the relationships between variables [7], it also allows the effects of manipulating a single variable to be isolated and analyzed singly.

The main disadvantage is the difficulty of experimenting with more than two factors, or many levels. A factorial design [8] has to be planned meticulously, as an error [9] in one of the levels, or in the general operationalization [10], will jeopardize a great amount of work.

Other than these slight detractions, a factorial design is a mainstay of many scientific disciplines, delivering great results in the field.

Links
[1] https://explorable.com/conducting-an-experiment
[2] https://explorable.com/steps-of-the-scientific-method
[3] https://explorable.com/statistics-tutorial
[4] https://explorable.com/design-of-experiment
[5] https://explorable.com/type-I-error
[6] https://explorable.com/confounding-variables
[7] https://explorable.com/relationship-between-variables
[8] http://www.socialresearchmethods.net/kb/expfact.php
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