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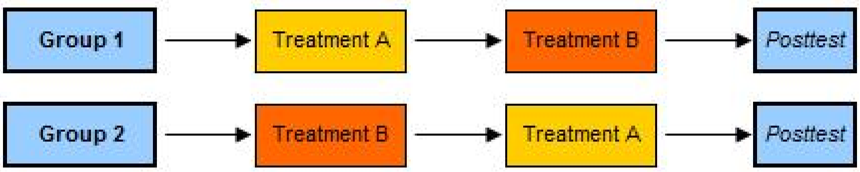
Counterbalanced Measures Design

Experiments conducted with a counterbalanced measures design are one of the best ways to avoid the pitfalls of standard repeated measures designs, where the subjects are exposed to all of the treatments.

In a normal experiment, the order in which treatments are given can actually affect the behavior of the subjects or elicit a false response, due to fatigue or outside factors changing the behavior of many of the subjects. To counteract this, researchers often use a counterbalanced design, which reduces the chances of the order of treatment or other factors adversely influencing the results.

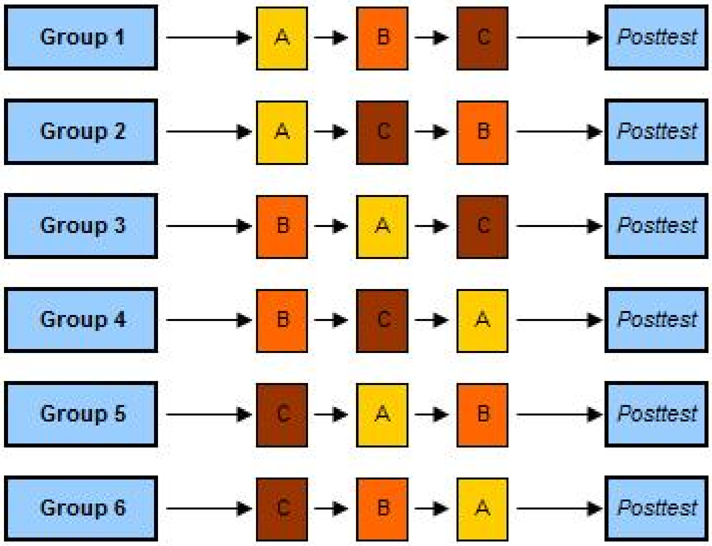
What is a Counterbalanced Measures Design?

The simplest type of counterbalanced measures design is used when there are two possible conditions, A and B. As with the standard repeated measures design, the researchers want to test every subject for both conditions. They divide the subjects into two groups and one group is treated with condition A, followed by condition B, and the other is tested with condition B followed by condition A.



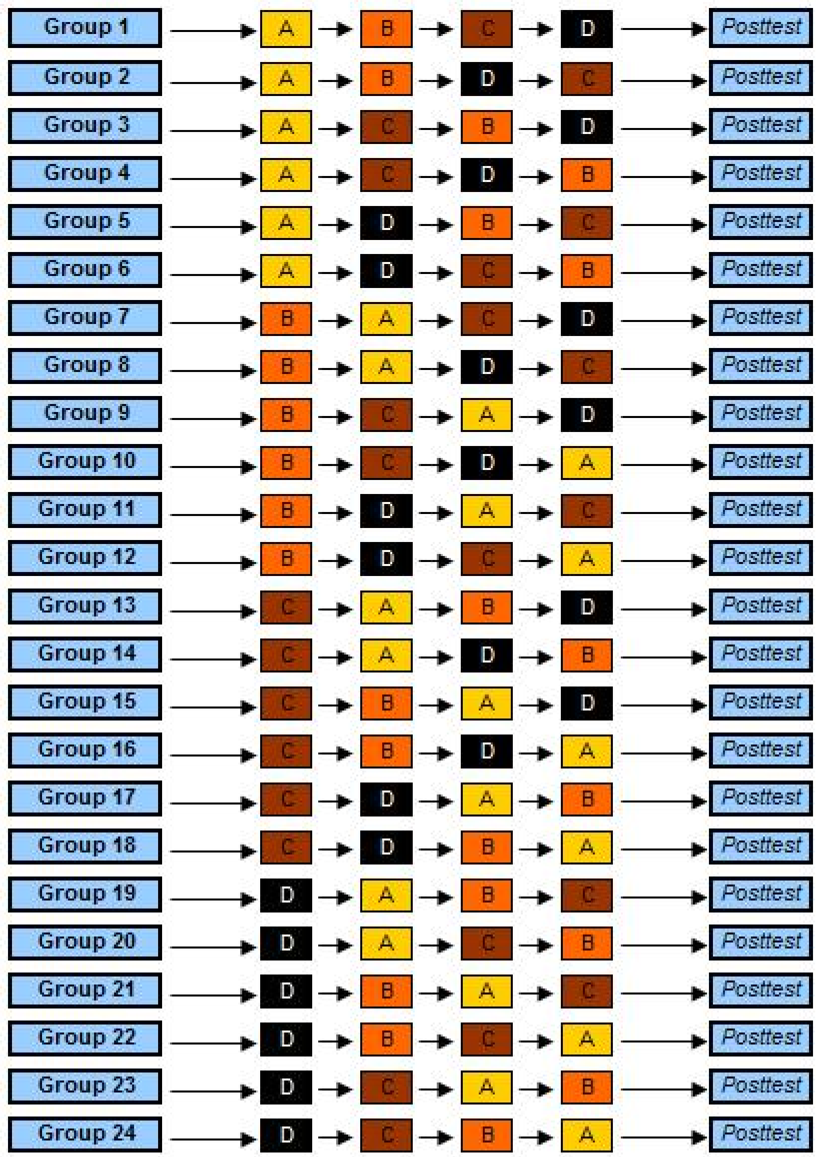
Three Conditions

If you have three conditions, the process is exactly the same and you would divide the subjects into 6 groups, treated as orders ABC, ACB, BAC, BCA, CAB and CBA.



Four Conditions

The problem with complete counterbalancing is that for complex experiments, with multiple conditions, the permutations quickly multiply and the research project becomes extremely unwieldy. For example, four possible conditions requires 24 orders of treatment (4x3x2x1), and the number of participants must be a multiple of 24, due to the fact that you need an equal number in each group.



More Than Four Conditions

With 5 conditions you need multiples of 120 (5x4x3x2x1), with 7 you need 5040! Therefore, for all but the largest research projects with huge budgets, this is impractical and a compromise is needed.

Incomplete Counterbalanced Measures Designs

Incomplete counterbalanced measures designs are a compromise, designed to balance the strengths of counterbalancing with financial and practical reality. One such incomplete counterbalanced measures design is the Latin Square, which attempts to circumvent some of the complexities and keep the experiment to a reasonable size.

With Latin Squares, a five-condition research program would look like this:

	Position 1	Position 2	Position 3	Position 4	Position 5
Order 1	A	B	C	D	E
Order 2	B	C	D	E	A

Order 3	C	D	E	A	B
Order 4	D	E	A	B	C
Order 5	E	A	B	C	D

The Latin Square design has its uses and is a good compromise for many research projects. However, it still suffers from the same weakness as the standard repeated measures design in that carryover effects are a problem. In the Latin Square, A always precedes B, and this means that anything in condition A that potentially affects B will affect all but one of the orders. In addition, A always follows E, and these interrelations can jeopardize the validity [1] of the experiment.

The way around this is to use a balanced Latin Square, which is slightly more complicated but ensures that the risk of carryover effects is much lower. For experiments with an even number of conditions, the first row of the Latin Square will follow the formula 1, 2, n, 3, n-1, 4, n-2…, where n is the number of conditions. For subsequent rows, you add one to the previous, returning to 1 after n.

Sounds complicated, so it is much easier to look at an example for a six condition experiment. The subject groups are labelled A to F, the columns represent the conditions tested, and the rows represent the subject groups:

Subjects	1st	2nd	3rd	4th	5th	6th
A	1	2	6	3	5	4
B	2	3	1	4	6	5
C	3	4	2	5	1	6
D	4	5	3	6	2	1
E	5	6	4	1	3	2
F	6	1	5	2	4	3

As you can see, this ensures that every single condition follows every other condition once, allowing the researchers to pick out any carryover effects during the statistical analysis.

When an experiment with an odd number of conditions is designed, the process is slightly more complex and two Latin Squares are needed to avoid carryover effects. The first is created in exactly the same way and the second is a mirror image:

1	2	5	3	4
2	3	1	4	5
3	4	2	5	1
4	5	3	1	2
5	1	4	2	3

4	3	5	2	1
5	4	1	3	2

1	5	2	4	3
2	1	3	5	4
3	2	4	1	5

With this design, every single condition follows another two times, and statistical tests allow researchers to analyse the data. This balanced Latin Square is a commonly used instrument to perform large repeated measured designs and is an excellent compromise between maintaining validity [2] and practicality. There are other variations of counterbalanced measures designs, but these variations are by far the most common.

Related pages:

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Control Group [4]
