THE REPEATED MEASURES DESIGN

One of the most frequently used experimental designs in the health sciences ﬁeld is the repeated measures design.

DEFINITION A repeated measures design is one in which measurements of the same variable are made on each subject on two or more different occasions.

The different occasions during which measurements are taken may be either points in time or different conditions such as different treatments.

When to Use Repeated Measures

The usual motivation for using a repeated measures design is a desire to control for variability among subjects. In such a design each subject serves as its own control. When measurements are taken on only two occasions, we have the paired comparisons design that we discussed in Chapter 7. One of the most frequently encountered situations in which the repeated measures design is used is the situation in which the investigator is concerned with responses over time.

Advantages

The major advantage of the repeated measures design is, as previously mentioned, its ability to control for extraneous variation among subjects. An additional advantage is the fact that fewer subjects are needed for the repeated measures

design than for a design in which different subjects are used for each occasion on which measurements are made. Suppose, for example, that we have four treatments (in the usual sense) or four points in time on each of which we would like to have 10 measurements. If a different sample of subjects is used for each of the four treatments or points in time, 40 subjects would be required. If we are able to take measurements on the same subject for each treatment or point in time—that is, if we can use a repeated measures design—only 10 subjects would be required. This can be a very attractive advantage if subjects are scarce or expensive to recruit.

Disadvantages

A major potential problem to be on the alert for is what is known as the carry-over effect. When two or more treatments are being evaluated, the investigator should make sure that a subject’s response to one treatment does not reﬂect a residual effect from previous treatments. This problem can frequently be solved by allowing a sufﬁcient length of time between treatments.

Another possible problem is the position effect. A subject’s response to a treatment experienced last in a sequence may be different from the response that would have occurred if the treatment had been ﬁrst in the sequence. In certain studies, such as those involving physical participation on the part of the subjects, enthusiasm that is high at the beginning of the study may give way to boredom toward the end. A way around this problem is to randomize the sequence of treatments independently for each subject.

Single-Factor Repeated Measures Design

The simplest repeated measures design is the one in which, in addition to the treatment variable, one additional variable is considered. The reason for introducing this additional variable is to measure and isolate its contribution to the total variability among the observations. We refer to this additional variable as a factor.

DEFINITION The repeated measures design in which one additional factor is introduced into the experiment is called a single-factor repeated measures design.

We refer to the additional factor as subjects. In the single-factor repeated measures design, each subject receives each of the treatments. The order in which the subjects are exposed to the treatments, when possible, is random, and the randomization is carried out independently for each subject.

Assumptions

The following are the assumptions of the single-factor repeated measures design that we consider in this text. A design in which these assumptions are met is called a ﬁxed-effects additive design.

1. The subjects under study constitute a simple random sample from a population of similar subjects.

2. Each observation is an independent simple random sample of size 1 from each of kn populations, where n is the number of subjects and k is the number of treatments to which each subject is exposed.

3. The kn populations have potentially different means, but they all have the same variance.

4. The k treatments are ﬁxed; that is, they are the only treatments about which we have an interest in the current situation. We do not wish to make inferences to some larger collection of treatments.

5. There is no interaction between treatments and subjects; that is, the treatment and subject effects are additive.

Experimenters may ﬁnd frequently that their data do not conform to the assumptions of ﬁxed treatments and/or additive treatment and subject effects. For such cases the references at the end of this chapter may be consulted for guidance.

In addition to the assumptions just listed, it should be noted that in a repeatedmeasures experiment there is a presumption that correlations should exist among the repeated measures. That is, measurements at time 1 and 2 are likely correlated, as are measurements at time 1 and 3, 2 and 3, and so on. This is expected because the measurements are taken on the same individuals through time.

An underlying assumption of the repeated-measures ANOVA design is that all of these correlations are the same, a condition referred to as compound symmetry. This assumption, coupled with assumption 3 concerning equal variances, is referred to as sphericity. Violations of the sphericity assumption can result in an inﬂated type I error. Most computer programs provide a formal test for the sphericity assumption along with alternative estimation methods if the sphericity assumption is violated.

The Model

ures design is

The model for the ﬁxed-effects additive single-factor repeated meas-

x ij = m + b i + t j + Pij

(8.4.1)

i = 1, 2, Á , n;

j = 1, 2, Á , k

The reader will recognize this model as the model for the randomized complete block design discussed in Section 8.3. The subjects are the blocks. Consequently, the notation, data display, and hypothesis testing procedure are the same as for the randomized complete block design as presented earlier. The following is an example of a repeated measures design.