The designs described so far have all been between-participants designs, that is, the participants in each condition were different. We now consider the use of **correlated-groups designs**, designs in which the participants in the experimental and control groups are related. There are two types of correlated-groups designs: within-participants designs and matched-participants designs. In addition, we will consider developmental designs, most commonly used by developmental psychologists. These designs differ from those already described in that they use age as a variable.

correlated-groups design: An experimental design in which the participants in the experimental and control groups are related in some way.

WITHIN-PARTICIPANTS EXPERIMENTAL DESIGNS

within-participants design: A type of correlated-groups design in which the same participants are used in each condition.

In a **within-participants design** the same participants are used in all conditions. Within-participants designs are often referred to as *repeated-measures designs* because we are repeatedly measuring the same individuals. A random sample of participants is selected, but random assignment is not relevant or necessary because all participants serve in all conditions. Within-participants designs are popular in psychological research for several reasons.

First, within-participants designs typically require fewer participants than between-participants designs. For example, we could conduct the mnemonic devices study using a between-participants design and randomly assign different people to the control condition (no mnemonic device) and the experimental condition (those using a mnemonic device). If we wanted 20 participants in each condition, we would need a minimum of 20 people to serve in the control condition and 20 to serve in the experimental condition for a total of 40 participants. If we conducted the experiment using a within-participants design, we would need only 20 participants who would serve in both the control and experimental conditions. Because participants for research studies are difficult to recruit, using a within-participants design to minimize the number of participants needed is advantageous.

Second, within-participants designs usually require less time to conduct than between-participants designs. The study is conducted more quickly because participants can usually take part in all conditions in one session; the experimenter does not use a participant in one condition and then wait around for the next person to participate in the next condition. Further, the instructions need to be given to each participant only once. If there are 10 participants in a within-participants design and participants are run individually, the experiment need only be explained 10 times. If there are 10 participants in each condition in a between-participants design in which participants are run individually, the experiment needs to be explained 20 times.

Third, and most important, within-participants designs increase statistical power. When the same individuals participate in multiple conditions, individual differences between the conditions are minimized. This minimization of differences in turn reduces variability and increases the chances of achieving statistical significance. Think about it this way. In a between-participants design the differences between the groups or conditions may be mainly due to the independent variable. Some of the difference between the performances of the two groups, however, is due to the fact that the individuals in one group are different from the individuals in the other group. This difference is referred to as *variability due to individual differences*. In a within-participants design, however, most variability between the two conditions (groups) must come from the manipulation of the independent variable because both groups of scores are produced by the same participants. The differences between the groups cannot be caused by individual differences because the scores in both conditions come from the same person. Because of the reduction in individual differences (variability), a within-participants design has greater statistical power than a between-participants design—it provides a purer measure of the true effects of the independent variable.

Although the within-participants design has advantages, it also has weaknesses. First, within-participants designs are open to many types of confounds. As with between-participants designs internal validity is a concern for within-participants designs. In fact, several of the confounds described in the previous module are especially troublesome for within-participants designs. For instance, testing effects, called **order effects** in a within-participants design, are more problematic because all participants are measured at least twice: in the control condition and in the experimental condition. Because of the multiple testing both practice and fatigue effects are common.

order effects: A problem for within-participants designs in which the order of the conditions has an effect on the dependent variable.

counterbalancing: A mechanism for controlling order effects either by including all orders of treatment presentation or by randomly determining the order for each participant.

Still, the effects can be equalized across conditions in a within-participants design by **counterbalancing**, that is, systematically varying the order of conditions for participants in a within-participants experiment. So if our memory experiment were counterbalanced, half of the people would participate in the control condition first, and the other half would participate in the experimental condition first. In this manner practice and fatigue effects would be evenly distributed across conditions.

When experimental designs are more complicated (i.e., they have three, four, or more conditions), counterbalancing can become more cumbersome. For example, a design with three conditions has 6 possible orders ($3! = 3 \times 2 \times 1$) in which to present the conditions, a design with four conditions has 24 ($4! = 4 \times 3 \times 2 \times 1$) possible orderings for the conditions, and a design with five conditions has 120 possible orderings ($5! = 5 \times 4 \times 3 \times 2 \times 1$). Given that most research studies use a limited number of participants in each condition (usually 20 to 30), it is not possible to use all of the orderings of conditions (called *complete counterbalancing*) in studies with four or more conditions. Luckily there are alternatives to complete counterbalancing, known as partial counterbalancing. One partial counterbalancing alternative is to randomize the order of presentation of conditions for each participant. Another is to randomly select the number of orders that matches the number of participants. For instance, in a study with four conditions and 24 possible orderings, if we had 15 participants, we could randomly select 15 of the 24 possible orderings.

Latin square: A counterbalancing technique to control for order effects without using all possible orders.

A more formal way to use partial counterbalancing is to construct a **Latin square**, which utilizes a limited number of orders. When using a Latin square, we have the same number of orders as we have conditions. Thus a Latin square for a design with four conditions uses 4 orders rather than the 24 orders necessary to completely counterbalance a design with four conditions. Another criterion that must be met when constructing a Latin square is that each condition should be presented at each order. In other words, for a study with four conditions each condition should appear once in each ordinal position. In addition, in a Latin square, each condition should precede and follow every other condition once. A Latin square for a study with four conditions appears in Table 13.1. The conditions are designated A, B, C, and D so that you can see how the order of conditions changes in each of the four orders used; however, once the Latin square is constructed using the letter symbols, each of the four conditions is randomly assigned to one of the letters to determine which condition will be A, B, and so on. A more complete discussion of Latin square designs can be found in Keppel (1991).

Another type of testing effect often present in within-participants designs is known as a *carryover effect*; that is, participants "carry" something with them from one condition to another. As a result of participating in one condition, they experience a change that they now carry with them to the second condition. Some drug research may involve carryover effects. The effects of the drug received in one condition are present for a while and may be carried to the next condition. Our memory experiment would probably also involve a carryover effect. If individuals participate in the control condition first (no mnemonic) and then the experimental condition (using a mnemonic device), there probably would not be a carryover effect. If some individuals participate in the experimental condition first, however, it would be difficult not to continue using the mnemonic device once they have learned it. What they learned in one condition is carried with them to the next condition and alters their performance in it. Counterbalancing enables the experimenter to assess the extent of carryover effects by comparing performance in the experimental condition when presented first versus second. Using a matched-participants design (to be discussed next) eliminates carryover effects.

Finally, within-participants designs are more open to demand characteristics, the information the participant infers about what the researcher wants.

TABLE **13.1**

A Latin Square for a Design with Four Conditions

Order of Conditions			
A	B	D	C
B	C	A	D
C	D	B	A
D	A	C	B

Note: The four conditions in this experiment are randomly given the letter designations A, B, C, and D.

Because individuals participate in all conditions, they know how the instructions vary by condition and how each condition differs from the previous ones. This knowledge gives them information about the study that a participant in a between-participants design does not have. This information in turn may enable them to determine the purpose of the investigation and could lead to a change in their performance.

Not all research can be conducted using a within-participants design. Most drug research is conducted using different participants in each condition because drugs often permanently affect or change an individual. Consequently participants cannot serve in more than one condition. In addition, researchers who study reasoning and problem solving often cannot use within-participants designs because, once a participant has solved a problem, they cannot serve in another condition that requires them to solve the same problem again. Where possible, however, many psychologists choose to use within-participants designs because they believe the added strengths of the design outweigh the weaknesses.

MATCHED-PARTICIPANTS EXPERIMENTAL DESIGNS

matched-participants design: A type of correlated-groups design in which participants are matched between conditions on variable(s) that the researcher believes is (are) relevant to the study.

The second type of correlated-groups design is a **matched-participants design**, which shares certain characteristics with both between- and within-participants designs. As in a between-participants design different participants are used in each condition. Yet for each participant in one condition, there is a participant in the other condition(s) who matches him or her on some relevant variable or variables. For example, if weight is a concern in a study and the researchers want to ensure that for each participant in the control condition there is a participant of the same weight in the experimental condition, they match participants on weight. Matching the participants on one or more variables makes the matched-participants design similar to the within-participants design. A within-participants design has perfect matching because the same people serve in each condition, whereas with the matched-participants design we are attempting to achieve as much equivalence between groups of different participants as we can.

Why then do we not simply use a within-participants design? The answer is usually carryover effects. Taking part in one condition changes the participants in such a way that they cannot take part in the second condition. For instance, drug research usually utilizes between-participants designs or matched-participants designs but rarely within-participants designs. Participants cannot take both the placebo and the real drug as part of an experiment; hence, this type of research requires that different people serve in each condition. But to ensure equivalency between groups, the researcher may choose to use a matched-participants design.

The matched-participants design has advantages over both between-participants and within-participants designs. First, because there are different people in each group, testing effects and demand characteristics are minimized in comparison to a within-participants design. Second, the groups are more equivalent than those in a between-participants design and almost as equivalent as those in a within-participants design. Third, because participants have been matched on variables of importance to the study, the same types of statistics used for the within-participants designs are used for the matched-participants designs. In other words, data from a matched-participants design are treated like data from a within-participants design. This similarity in data analysis means that a matched-participants design is as powerful as a within-participants design because individual differences have been minimized.

Of course, matched-participants designs also have weaknesses. First, more participants are needed than in a within-participants design. Second, if one participant in a matched-participants design drops out, the entire pair is lost. Thus mortality is even more of an issue in matched-participants designs than in other designs. Finally, the biggest weakness of the matched-participants design is the matching itself. Finding an individual willing to participate in an experiment who exactly (or very closely) matches another participant on a specific variable can be difficult. If the researcher is matching participants on more than one variable (say, height and weight), it becomes even more difficult. Because participants are hard to find, it is very difficult to find enough matched participants to take part in a matched-participants study.

IN REVIEW Comparison of Designs

	Within-Participants Design	Matched-Participants Design
Description	The same participants are used in all conditions	Participants are randomly assigned to each condition after being matched on relevant variables
Strengths	Fewer participants needed	Testing effects minimized
	Less time-consuming	Demand characteristics minimized
	Equivalency of groups ensured	Groups are fairly equivalent
	More powerful statistically	More powerful statistically
Weaknesses	Probability of testing effects is high	Matching is very difficult
	Probability of demand characteristics is high	More participants are needed

CRITICAL THINKING CHECK 13.1

1. If a researcher wants to conduct a study with four conditions and 15 participants in each condition, how many participants are needed for a between-participants design? For a within-participants design? For a matched-participants design?
2. People with anxiety disorders are selected to participate in a study on a new drug for the treatment of these disorders. The researchers know that the drug is effective in treating them, but they are concerned with possible side effects. In particular, they are concerned with the effects of the drug on cognitive abilities. Therefore they ask each participant in the experiment to identify a family member or friend of the same

(continues)