Mean

The **mean** in each group or condition is calculated by adding up all the scores in a given condition, and then dividing by the number of participants in that condition. Suppose that the scores of the nine participants in the no-noise condition are as follows: 1, 2, 4, 5, 7, 9, 9, 9, 17. The mean is given by the total, which is 63, divided by the number of participants, which is 9. Thus, the mean is 7.

Mean

Scores	Number	
1	1	
2	2	
4	3	
5	4	
7	5	
9	6	
9	7	
9	8	
17	9	
63	9	Total

63 ÷ 9 = 7

The main advantage of the mean is the fact that it takes all the scores into account. This generally makes it a sensitive measure of central tendency, especially if the scores resemble the **normal distribution**, which is a bell-shaped distribution in which most scores cluster fairly close to the mean. However, the mean can be very misleading if the distribution differs markedly from the normal and there are one or two extreme scores in one direction. Suppose that eight people complete one lap of a track in go-karts. For seven of them, the times taken (in seconds) are as follows: 25, 28, 29, 29, 34, 36, and 42. The eighth person's go-kart breaks down, and so the driver has to push it around the track. This person takes 288 seconds to complete the lap. This produces an overall mean of 64 seconds. This is clearly misleading, because no one else took even close to 64 seconds to complete one lap.

Median

Another way of describing the general level of performance in each condition is known as the **median**. If there is an odd number of scores, then the median is simply the middle score, having an equal number of scores higher and lower than it. In the example with nine scores in the no-noise condition (1, 2, 4, 5, 7, 9, 9, 9, 17), the median is 7. Matters are slightly more complex if there is an even number of scores. In that case, we work out the mean of the two central values. For example, suppose that we have the following scores in size order: 2, 5, 5, 7, 8, 9. The two central values are 5 and 7, and so the median is

Scores
1
2
4
5
7 = Median
9
9
9
17

$$\frac{5+7}{2} = 6$$

The main advantage of the median is that it is unaffected by a few extreme scores, because it focuses only on scores in the middle of the distribution. It also has the advantage that it tends to be easier than the mean to work out. The main limitation of the median is that it ignores most of the scores, and so it is often less sensitive than the mean. In addition, it is not always representative of the scores obtained, especially if there are only a few scores.

Scores
1
2
4
5
7
9
9 = Mode
9
17

Mode

The final measure of central tendency is the **mode**. This is simply the most frequently occurring score. In the example of the nine scores in the no-noise condition, this is 9. The main advantages of the mode are that it is unaffected by one or two extreme scores, and that it is the easiest measure of central tendency to work out. In addition, it can still be worked out even when some of the extreme scores are not known. However, its limitations generally outweigh these advantages. The greatest limitation is that the mode tends to be unreliable. For example, suppose we have the following scores: 4, 4, 6, 7, 8, 8, 12, 12, 12. The mode of these scores is 12. If just one score changed (a 12 becoming a 4), the mode would change to 4! Another limitation is that information about the exact values of the scores obtained is ignored in working out the mode. This makes it a less sensitive measure than the mean. A final limitation is that it is possible for there to be more than one mode.

Key Terms

Mean:
an average worked out by dividing the total of all participants' scores by the number of participants.

Normal distribution:
a bell-shaped distribution in which most scores cluster fairly close to the mean.

Median:
the middle score out of all participants' scores in a given condition.

Mode:
the most frequently occurring score among the participants in a given condition.

The mode is useful where other measures of central tendency are meaningless, for example when calculating the number of children in the average family. It would be unusual to have 0.4 or 0.6 of a child!

Levels of measurement

From what has been said so far, we have seen that the mean is the most generally useful measure of central tendency, whereas the mode is the least useful. However, we need to take account of the level of measurement when deciding which measure of central tendency to use (the various levels are discussed further on pp. 598–599 of this chapter). At the interval and ratio levels of measurement, each added unit represents an equal increase. For example, someone who hits a target four times out of ten has done twice as well as someone who hits it twice out of ten. Below this is the ordinal level of measurement, in which we can only order, or rank, the scores from highest to lowest. At the lowest level, there is the nominal level, in which the scores consist of the numbers of participants falling into various categories. The mean should only be used when the scores are at the interval level of measurement. The median can be used when the data are at the interval or ordinal level. The mode can be used when the data are at any of the three levels. It is the only one of the three measures of central tendency that can be used with nominal data.

MEASURES OF DISPERSION

The mean, median, and mode are all measures of central tendency. It is also useful to work out what are known as measures of dispersion, such as the range, interquartile range, variation ratio, and standard deviation. These measures indicate whether the scores in a given condition are similar to each other or whether they are spread out.

Range

The simplest of these measures is the **range**, which can be defined as the difference between the highest and the lowest score in any condition. In the case of the no-noise group (1, 2, 4, 5, 7, 9, 9, 9, 17), the range is 17 – 1 = 16.

In fact, it is preferable to calculate the range in a slightly different way (Coolican, 1994). The revised formula (when we are dealing with whole numbers) is as follows: (highest score – lowest score) +1. Thus, in our example, the range is (17 – 1) +1 = 17. This formula is preferable because it takes account of the fact that the scores we recorded were rounded to whole numbers. In our sample data, a score of 17 stands for all values between 16.5 and 17.5, and a score of 1 represents a value between 0.5 and 1.5. If we take the range as the interval between the highest possible value (17.5) and the lowest possible value (0.5), this gives us a range of 17, which is precisely the figure produced by the formula.

Range									9								
									9								
Scores:	1	2		4	5		7		9								17
Range:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

What has been said so far about the range applies only to whole numbers. Suppose that we measure the time taken to perform a task to the nearest one-tenth of a second, with the fastest time being 21.3 seconds and the slowest time being 36.8 seconds. The figure of 21.3 represents a value between 21.25 and 21.35, and 36.8 represents a value between 36.75 and 36.85. As a result, the range is 36.85 – 21.25, which is 15.6 seconds.

The main advantages of the range as a measure of dispersion are that it is easy to calculate and that it takes full account of extreme values. The main weakness of the range is that it can be greatly influenced by one score that is very different from all of the others. In the example, the inclusion of the participant scoring 17 increases the range from 9 to 17. The other important weakness of the range is that it ignores all but two of the scores, and so is likely to provide an inadequate measure of the general spread or dispersion of the scores around the mean or median.

Key Term

Range:
the difference between the highest and lowest score in any condition.

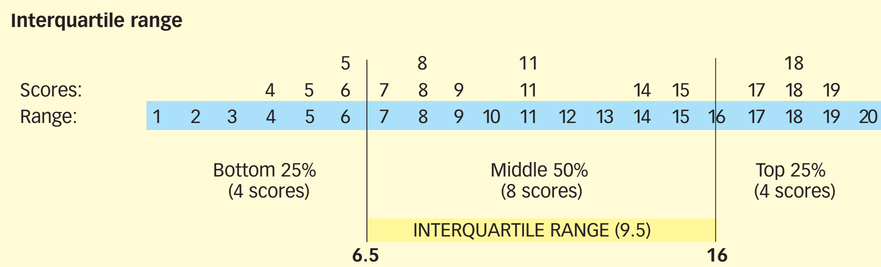
Range

Suppose that the scores obtained in a study were as follows:

Group A: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 total = 275
Mean = 27.5
Median = 27.5

Group B: 15, 20, 20, 25, 25, 30, 35, 35, 35, 35 total = 275
Mean = 27.5
Median = 27.5

Although the means and medians are the same for both sets of scores, the spread of scores is quite different. This becomes highly relevant if we are assessing something like the range of abilities in children in a class.



Interquartile range

The **interquartile range** is defined as the spread of the middle 50% of scores. For example, suppose that we have the following set of scores: 4, 5, 6, 6, 7, 8, 8, 9, 11, 11, 14, 15, 17, 18, 18, 19. There are 16 scores, which can be divided into the bottom 25% (4), the middle 50% (8), and the top 25% (4). The middle 50% of scores start with 7 and run through to 15. The upper boundary of the interquartile range lies between 15 and 17, and is given by the mean of these two values, i.e., 16. The lower boundary of the interquartile range lies between 6 and 7, and is their mean; i.e., 6.5. The interquartile range is the difference between the upper and lower boundaries, i.e., 16 – 6.5 = 9.5.

The interquartile range has the advantage over the range that it is not influenced by a single extreme score. As a result, it is more likely to provide an accurate reflection of the spread or dispersion of the scores. It has the disadvantage that it ignores information from the top and the bottom 25% of scores. For example, we could have two sets of scores with the same interquartile range, but with more extreme scores in one set than in the other. The difference in spread or dispersion between the two sets of scores would not be detected by the interquartile range.

Standard deviation

The most generally useful measure of dispersion is the **standard deviation**. It is harder to calculate than the range but generally provides a more accurate measure of the spread of scores. However, you will be pleased to learn that many calculators allow the standard deviation to be worked out rapidly and effortlessly, as in the worked example.

The first step is to work out the mean of the sample. This is given by the total of all of the participants' scores ($\Sigma X = 130$; the symbol Σ means the sum of) divided by the number of participants ($N = 13$). Thus, the mean is 10.

The second step is to subtract the mean in turn from each score ($X - M$). The calculations are shown in the fourth column. The third step is to square each of the scores in the fourth column, $(X - M)^2$. The fourth step is to work out the total of all the squared scores, $\Sigma(X - M)^2$. This comes to 136. The fifth step is to divide the result of the fourth step by one less than the number of participants, $N - 1 = 12$. This gives us 136 divided by 12, which equals 11.33. This is known as the **variance**, which is in squared units. Finally, we use a calculator to take the square root of the variance. This produces a figure of 3.37; this is the standard deviation.

The method for calculating the standard deviation that has just been described is used when we want to estimate the standard deviation of the population. If we want merely to describe the spread of scores in our sample, then the fifth step involves dividing the result of the fourth step by N.

What is the meaning of this figure for the standard deviation? We expect about two-thirds of the scores in a sample to lie within one standard deviation of the mean. In

Key Terms

Interquartile range:
the spread of the middle 50% of an ordered or ranked set of scores.

Standard deviation:
a measure of the spread of scores in a bell-shaped or normal distribution. It is the square root of the variance, takes account of every score, and is a sensitive dispersion measure.

Variance:
a measure of dispersion that is the square of the standard deviation.

Standard deviation: A worked example

Participant	Score X	Mean M	Score − Mean X − M	(Score − Mean)^2 (X − M)^2
1	13	10	3	9
2	6	10	−4	16
3	10	10	0	0
4	15	10	5	25
5	10	10	0	0
6	15	10	5	25
7	5	10	−5	25
8	9	10	−1	1
9	10	10	0	0
10	13	10	3	9
11	6	10	−4	16
12	11	10	1	1
13	7	10	−3	9
13	130	10		136

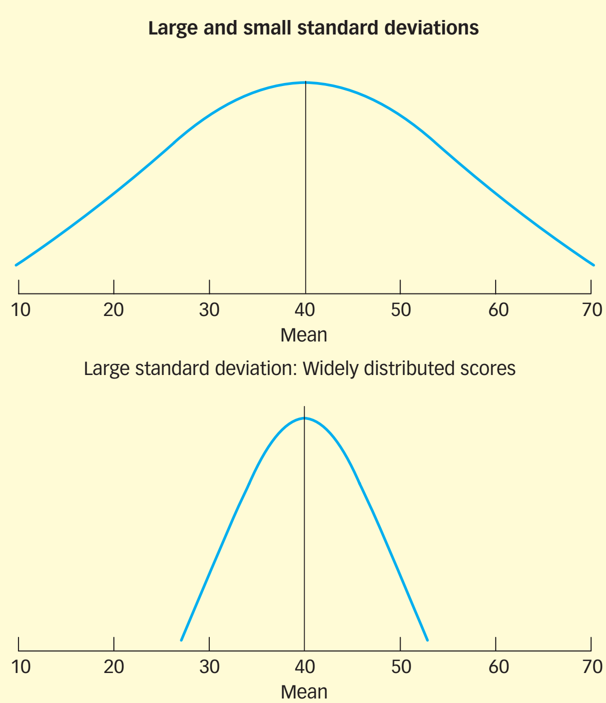
Total of scores = $\Sigma X = 130$

Number of participants = $N = 13$

Mean = $\frac{\Sigma X}{N} = \frac{130}{13} = 10$

Variance = $\frac{136}{13 - 1} = 11.33$

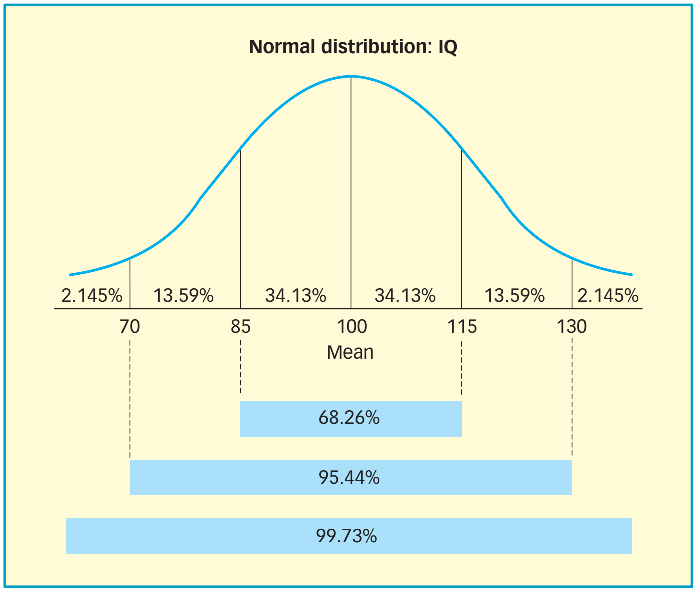
Standard deviation = $\sqrt{11.3} = 3.37$



Large standard deviation: Widely distributed scores

Small standard deviation: Closely distributed scores

our example, the mean is 10.0, one standard deviation above the mean is 13.366, and one standard deviation below the mean is 6.634. In fact, 61.5% of the scores lie between those two limits, which is only slightly below the expected percentage.



The standard deviation has special relevance in relation to the so-called normal distribution. As was mentioned earlier, the normal distribution is a bell-shaped curve in which there are as many scores above the mean as below it. Intelligence (or IQ) scores in the general population provide an example of a normal distribution. Other characteristics such as height and weight also form roughly a normal distribution. Most of the scores in a normal distribution cluster fairly close to the mean, and there are fewer and fewer scores as you move away from the mean in either direction. In a normal distribution, 68.26% of the scores fall within one standard deviation of the mean, 95.44% fall within two standard deviations, and 99.73% fall within three standard deviations.

The standard deviation takes account of all of the scores and provides a sensitive measure of dispersion. As we have seen, it also has the advantage that it describes the spread of scores in a normal distribution with great precision. The most obvious disadvantage of the standard deviation is that it is much harder to work out than the other measures of dispersion.

DATA PRESENTATION

Information about the scores in a sample can be presented in several ways. If it is presented in a graph or chart, this may make it easier for people to understand what has been found, compared to simply presenting information about the central tendency and dispersion. We will shortly consider some examples. The key point to remember is that all graphs and charts should be clearly labeled and presented so that the reader can rapidly make sense of the information contained in them.

Suppose that we ask 25 male athletes to run 400 meters as rapidly as possible, and record their times (in seconds). Having worked out a table of frequencies (see the boxed example below), there are several ways to present these data.

25 athletes running 400 meters

Raw data

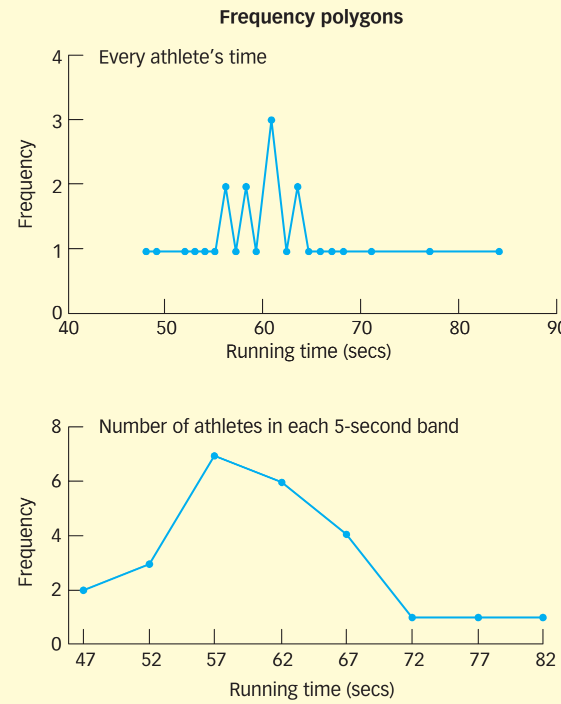
Athlete	1	2	3	4	5	6	7	8	9
Speed	71	77	84	49	63	62	56	67	52
Athlete	10	11	12	13	14	15	16	17	18
Speed	61	63	59	48	61	65	68	54	61
Athlete	19	20	21	22	23	24	25		
Speed	58	66	55	57	58	56	53		

Table of frequencies (number of athletes obtaining each speed)

Speed	48	49	52	53	54	55	56	57	58	59	61	62	63	65	66	67	68	71	77	84
Athlete no.	13	4	9	25	17	21	7 24	22	19 23	12	10 14 18	6	5 11	15	20	8	16	1	2	3
Number	1	1	1	1	1	1	2	1	2	1	3	1	2	1	1	1	1	1	1	1

FREQUENCY POLYGON

One way of summarizing these data is in the form of a **frequency polygon**. This is a simple form of chart in which the scores from low to high are indicated on the x or horizontal axis and the frequencies of the various scores (in terms of the numbers of individuals obtaining each score) are indicated on the y or vertical axis. The points on a frequency polygon should only be joined up when the scores can be ordered from low to high. In order for a frequency polygon to be most useful, it should be constructed so that most of the frequencies are neither very high nor very low. The frequencies will be very high if the width of each class interval (the categories used to summarize frequencies) on the x axis is too broad (e.g., covering 20 seconds), and the frequencies will be very low if each class interval is too narrow (e.g., covering only 1 or 2 seconds).



Each point in a frequency polygon should be placed in the middle of its class interval. There is a technical point that needs to be made here (Coolican, 1994). Suppose that we include all times between 53 and 57 seconds in the same class interval. As we have only measured running times to the nearest second, this class interval will cover actual times between 52.5 and 57.5 seconds. In this case, the mid-point of the class interval (55 seconds) is the same whether we take account of the actual measurement interval (52.5–57.5 seconds) or adopt the simpler approach of focusing on the lowest and highest recorded times in the class interval (53–57 seconds, respectively). When the two differ, it is important to use the actual measurement interval.

How should we interpret the findings shown in the frequency polygon? It is clear that most of the participants were able to run 400 meters in between about 53 and 67 seconds. Only a few of the athletes were able to better a time of 53 seconds, and there was a small number who took longer than 67 seconds.

Key Terms

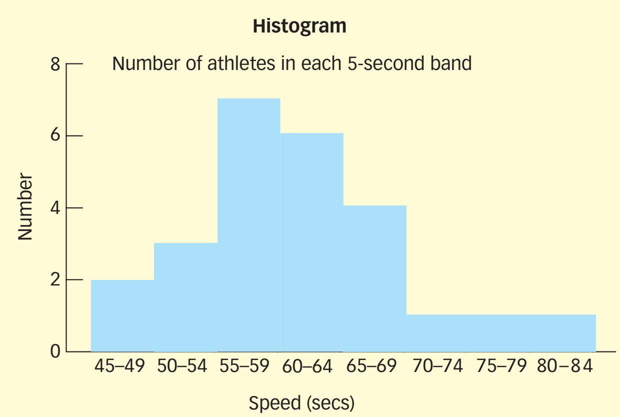
Frequency polygon: a graph showing the frequencies with which different scores are obtained by the participants in a study.

Histogram: a graph in which the frequencies with which different scores are obtained by the participants in a study are shown by rectangles of different heights.

HISTOGRAM

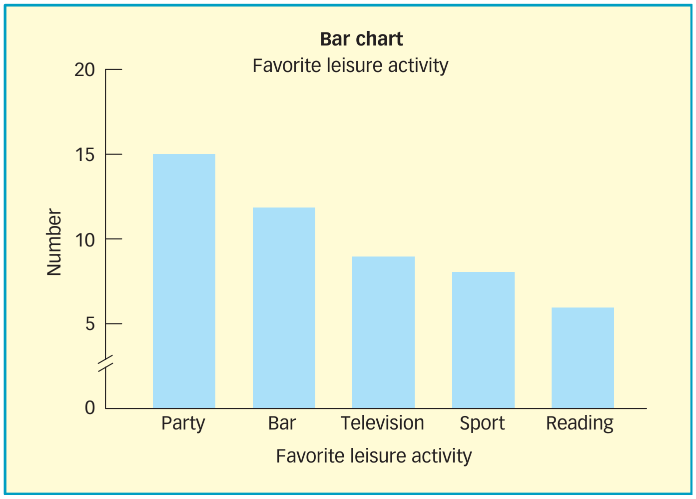
A similar way of describing these data is by means of a **histogram**. In a histogram, the scores are indicated on the horizontal axis and the frequencies are shown on the vertical axis. In contrast to a frequency polygon, however, the frequencies are indicated by rectangular columns. These columns are all the same width but vary in height in accordance with the corresponding frequencies. As with frequency polygons, it is important to make sure that the class intervals are not too broad or too narrow. All class intervals are represented, even if there are no scores in some of them. Class intervals are indicated by their mid-point at the center of the columns.

Histograms are clearly rather similar to frequency polygons. However, frequency polygons are sometimes preferable when you want to compare two different frequency distributions. The information contained in a histogram is interpreted in the same way as the information in a frequency polygon. In the present example, the histogram indicates that most of the athletes ran 400 meters fairly quickly. Only a few had extreme times.



BAR CHART

Frequency polygons and histograms are suitable when the scores obtained by the participants can be ordered from



low to high. In more technical terms, the data should be either interval or ratio (see next section). However, there are many studies in which the scores are in the form of categories rather than ordered scores; in other words, the data are nominal. For example, 50 people might be asked to indicate their favorite leisure activity. Suppose that 15 said going to a party, 12 said going to a bar, 9 said watching television, 8 said playing sport, and 6 said reading a good book.

These data can be displayed in the form of a **bar chart**. In a bar chart, the categories are shown along the horizontal axis, and the frequencies are indicated on the vertical axis. In contrast to the data contained in histograms, the categories in bar charts cannot be ordered numerically in a meaningful way. However, they can be arranged in ascending (or descending) order of popularity. Another difference from histograms is that the rectangles in a bar chart do not usually touch each other.

The scale on the vertical axis of a bar chart normally starts at zero. However, it is sometimes convenient for presentational purposes to have it start at some higher value. If that is done, then it should be made clear in the bar chart that the lower part of the vertical scale is missing. The columns in a bar chart often represent frequencies. However, they can also represent means or percentages for different groups (Coolican, 1994).

How should we interpret the information in a bar chart? In the present example, a bar chart makes it easy to compare the popularity of different leisure activities. We can see at a glance that going to a party was the most popular leisure activity, whereas reading a good book was the least popular.

STATISTICAL TESTS

The various ways in which the data from a study can be presented are all useful in that they give us convenient and easily understood summaries of what we have found. However, to have a clearer idea of what our findings mean, it is generally necessary to carry out one or more statistical tests. The first step in choosing an appropriate statistical test is to decide whether your data were obtained from an experiment in which some aspect of the situation (the independent variable) was manipulated in order to observe its effects on the dependent variables (i.e., the scores). If so, you need a test of difference (see pp. 600–605 of this chapter). On the other hand, if you simply have two observations from each of your participants in a nonexperimental design, then you need a test of association or correlation (see pp. 605–610 of this chapter).

In using a statistical test, you need to take account of the experimental hypothesis. If you predicted the direction of any effects (e.g., loud noise will disrupt learning and memory), then you have a directional hypothesis, which should be evaluated by a one-tailed test. If you did not predict the direction of any effects (e.g., loud noise will affect learning and memory), then you have a nondirectional hypothesis, which should be evaluated by a two-tailed test (see Chapter 24).

Another factor to consider when deciding which statistical test to use is the type of data you have obtained. There are four types of data of increasing levels of precision:

- **Nominal**: The data consist of the numbers of participants falling into various categories (e.g., fat, thin; men, women).
- **Ordinal**: The data can be ordered from lowest to highest (e.g., the finishing positions of athletes in a race).
- **Interval**: The data differ from ordinal data, because the units of measurement are fixed throughout the range; for

Key Terms

Bar chart:
a graph showing the frequencies with which the participants in a study fall into different categories.

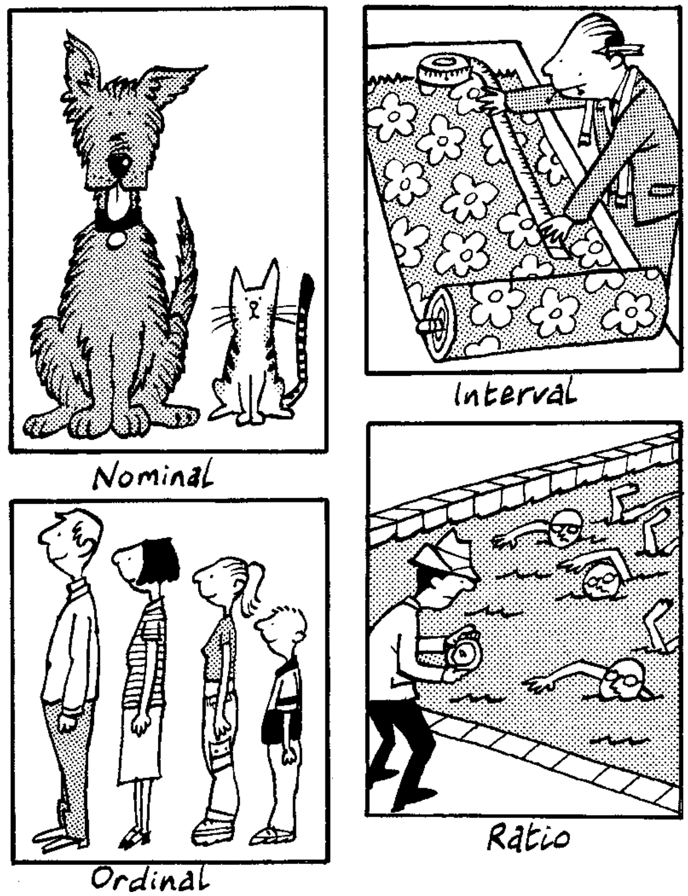
Nominal data:
data consisting of the numbers of participants falling into qualitatively different categories.

Ordinal data:
data that can be ordered from smallest to largest.

Interval data:
data in which the units of measurement have an invariant or unchanging value.

example, there is the same "distance" between a height of 1.82 meters and 1.70 meters as between a height of 1.70 meters and one of 1.58 meters.
- **Ratio:** The data have the same characteristics as interval data, with the exception that they have a meaningful zero point; for example, time measurements provide ratio data because the notion of zero time is meaningful, and 10 seconds is twice as long as 5 seconds. The similarities between interval and ratio data are so great that they are sometimes combined and referred to as interval/ratio data.

Statistical tests can be divided into **parametric tests** and **nonparametric tests**. Parametric tests should only be used when the data obtained from a study satisfy various requirements. More specifically, there should be interval or ratio data, the data should be normally distributed, and the variances in the two conditions should be reasonably similar. In contrast, nonparametric tests can nearly always continue to be used, even when the requirements of parametric tests are satisfied. In this chapter, we confine ourselves to a discussion of some of the most useful nonparametric tests.



STATISTICAL SIGNIFICANCE

So far we have discussed some of the issues that influence the choice of statistical test. What happens after we have chosen a statistical test, and analyzed our data, and want to interpret our findings? We use the results of the test to choose between the following:

- Experimental hypothesis (e.g., loud noise disrupts learning).
- Null hypothesis, which asserts that there is no difference between conditions (e.g., loud noise has no effect on learning).

If the statistical test indicates that there is only a small probability of the difference between conditions (e.g., loud noise vs. no noise) having occurred if the null hypothesis were true, then we reject the null hypothesis in favor of the experimental hypothesis.

Why do we focus initially on the null hypothesis rather than the experimental hypothesis? The reason is that the experimental hypothesis is rather imprecise. It may state that loud noise will disrupt learning, but it does not indicate the *extent* of the disruption. This imprecision makes it hard to evaluate an experimental hypothesis directly. In contrast, a null hypothesis such as loud noise has no effect on learning *is* precise, and this precision allows us to use statistical tests to decide the probability that it is correct.

Psychologists generally use the 5% (.05) level of **statistical significance**. What this means is that the null hypothesis is rejected (and the experimental hypothesis is accepted) if the probability that the results were due to chance alone is 5% or less. This is often expressed as $p = .05$, where $p =$ the probability of the result if the null hypothesis is true. If the statistical test indicates that the findings do not reach the 5% (or $p = .05$) level of statistical significance, then we retain the null hypothesis and reject the experimental hypothesis. The key decision is whether or not to reject the null hypothesis and that is why the .05 level

Key Terms

Ratio data:
as **interval data**, but with a meaningful zero point.

Parametric tests:
statistical tests that require interval or ratio data, normally distributed data, and similar variances in both conditions.

Nonparametric tests:
statistical tests that do not involve the requirements of parametric tests.

Statistical significance:
the level at which the decision is made to reject the **null hypothesis** in favor of the **experimental hypothesis**.

From percentage to decimal

10% = .10
5% = .05
1% = .01
2.5% = ?

To go from decimal to percentage, multiply by 100: move the decimal point two places to the right.

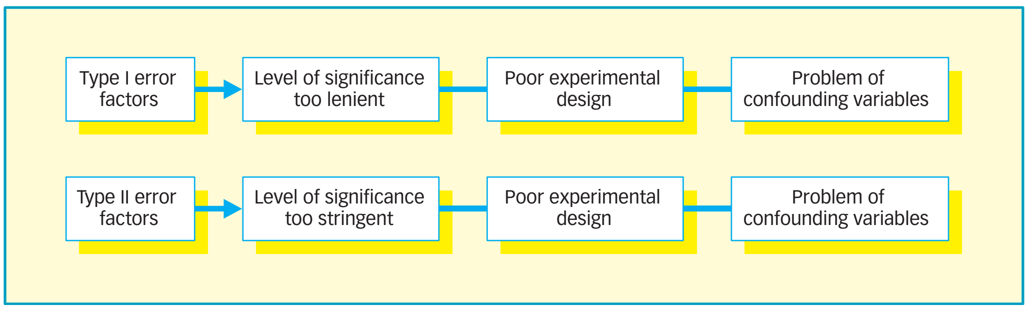
To go from percentage to decimal, divide by 100: move the decimal point two places to the left.

of statistical significance is so important. However, our data sometimes indicate that the null hypothesis can be rejected with greater confidence, say, at the 1% (.01) level. If the null hypothesis can be rejected at the 1% level, it is customary to state that the findings are highly significant. In general terms, you should state the precise level of statistical significance of your findings, whether it is the 5% level, the 1% level, or whatever.

These procedures may seem easy. In fact, there are two errors that may occur when reaching a conclusion on the basis of the results of a statistical test:

- **Type I error:** We may reject the null hypothesis in favor of the experimental hypothesis even though the findings are actually due to chance; the probability of this happening is given by the level of statistical significance that is selected.
- **Type II error:** We may retain the null hypothesis even though the experimental hypothesis is actually correct.

It would be possible to reduce the likelihood of a Type I error by using a more stringent level of significance. For example, if we used the 1% (p = .01) level of significance, this would greatly reduce the probability of a Type I error. However, use of a more stringent level of significance increases the probability of a Type II error. We could reduce the probability of a Type II error by using a less stringent level of significance, such as the 10% (p = .10) level. However, this would increase the probability of a Type I error. These considerations help to make it clear why most psychologists favor the 5% (or p = .05) level of significance: it allows the probabilities of both Type I and Type II errors to remain reasonably low.



Psychologists generally use the 5% level of significance. However, they would use the 1% or even the 0.1% level of significance if it were very important to avoid making a Type I error. For example, clinical psychologists might require very strong evidence that a new form of therapy was more effective than existing forms of therapy before starting to use it on a regular basis. The 1% or 0.1% (p = .001) level of statistical significance is also used when the experimental hypothesis seems improbable. For example, very few people would accept that telepathy had been proved to exist on the basis of a single study in which the results were only just significant at the 5% level!

TESTS OF DIFFERENCE

In this section, we consider those statistical tests that are applicable when we are interested in deciding whether the differences between two conditions or groups are significant. As discussed in Chapter 24, there are three kinds of design that can be used when we want to compare two conditions. First, there is the independent design, in which each participant is allocated at random to one and only one condition. Second, there is the repeated measures design, in which the same participants are used in both conditions. Third, there is the matched participants design, in which the participants in the two

Key Terms

Type I error:
mistakenly rejecting the null hypothesis in favor of the experimental hypothesis when the results are actually a result of chance.

Type II error:
mistakenly retaining the null hypothesis when the experimental hypothesis is actually correct.

conditions are matched in terms of some variable or variables that might be relevant (e.g., intelligence; age).

When deciding which statistical test to use, it is very important to take account of the particular kind of experimental design that was used. If the independent design has been used, then the Mann-Whitney U test is likely to be an appropriate test to use. If the repeated measures or matched participants design has been used, then the sign test or the Wilcoxon matched pairs signed ranks test is likely to be appropriate. Each of these tests is discussed in turn next.

Mann-Whitney U test

The Mann-Whitney U test can be used when an independent design has been used, and the data are either ordinal or interval. The worked example in the box shows how this test is calculated.

Suppose that we have two conditions. In both conditions, the participants have to fire arrows at a board, and the score obtained is recorded. There are 10 participants in Condition A, in which no training is provided before their performance is assessed. There

Mann-Whitney U test: A worked example

Experimental hypothesis: Extensive training improves performance
Null hypothesis: Training has no effect on performance

Participant	Condition A	Rank	Participant	Condition B	Rank
1	4	2	1	21	15
2	10	9	2	26	18
3	12	11	3	20	14
4	28	20	4	22	16
5	7	5	5	32	22
6	13	13	6	5	3
7	12	11	7	12	11
8	2	1	8	6	4
9	9	7.5	9	8	6
10	27	19	10	24	17
			11	29	21
			12	9	7.5

Smaller sample = condition A

Sum of ranks in smaller sample (T) = 98.5

Number of participants in smaller sample (N_A) = 10

Number of participants in larger sample (N_B) = 12

Formula: $U = N_A N_B + \left(\frac{N_A(N_A + 1)}{2}\right) - T$

Example: $U = (10 \times 12) + \left(\frac{10(10 + 1)}{2}\right) - 98.5 = 76.5$

Formula for calculating U′: $U' = N_A N_B = U$

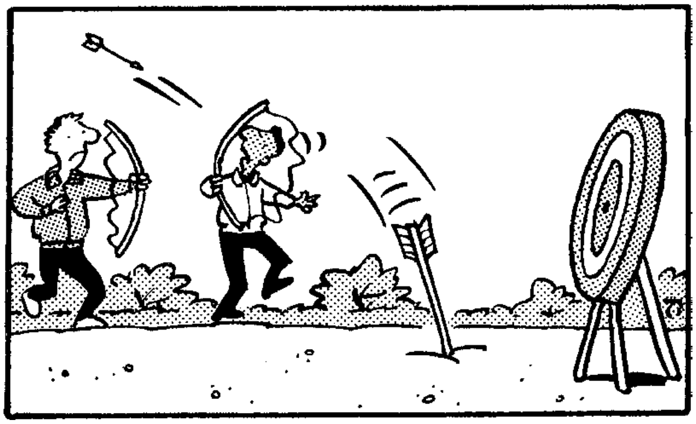
Example: $U' = (10 \times 12) - 76.5 = 43.5$

Comparing U and U′, U′ is the smaller value. The calculated value of U′ (43.5) is checked against the tabled value for a one-tailed test at 5%.

Table values

	$N_A = 10$
$N_B = 12$	34

Conclusion: As 43.5 is greater than 34, the null hypothesis should be retained—i.e., training has no effect on performance in this task.



are 12 participants in Condition B, and they receive extensive training before their performance is assessed. The experimental hypothesis was that extensive training would improve performance; in other words, the scores in Condition B should be significantly higher than those in Condition A.

The first step is to rank all of the scores from both groups together, with a rank of 1 being given to the smallest score, a rank of 2 to the second smallest score, and so on. If there are tied scores, then the mean of the ranks involved is given to each of the tied participants. For example, two participants were tied for the 7th and 8th ranks, and so they both received a rank of 7.5.

The second step is to work out the sum of the ranks in the smaller sample, which is Condition A in our example. This value is known as T, and it is 98.5 in the example.

The third step is to calculate U from the formula in which N_A is the number of participants in the smaller sample and N_B is the number in the larger sample.

$$U = N_A N_B + \left(\frac{N_A(N_A + 1)}{2}\right) - T$$

The fourth step is to calculate U′ from the formula $U' = N_A N_B - U$.

The fifth step is to compare U and U′, selecting whichever is the smaller value provided that the results are in the correct direction. The smaller value (i.e., 43.5) is then looked up in Appendix 1. The observed value must be equal to, or smaller than, the tabled value in order to be significant. In this case, we have a one-tailed test, because the experimental hypothesis stated that extensive training would improve performance and the statistical significance is the standard 5% (.05). With 10 participants in our first condition and 12 in our second condition, the tabled value for significance is 34 (value obtained from the table at the bottom of p. 621 of the Appendices). As our value of 43.5 is greater than 34, the conclusion is that we retain the null hypothesis. It should be noted that the presence of ties reduces the accuracy of the tables, but the effect is small unless there are several ties.

Sign test

The sign test can be used when a repeated measures or matched participants design has been used, and the data are ordinal. If the data are interval or ratio, then it would be more appropriate to use the Wilcoxon matched pairs signed ranks test. The worked example in the box opposite illustrates the way in which the sign test is calculated.

Suppose that there were 12 participants in an experiment. In Condition A these participants were presented with 20 words to learn in a situation with no noise; learning was followed 5 minutes later by a test of free recall in which they wrote down as many words as they could remember in any order. Condition B involved presenting 20 different words to learn in a situation of loud noise, again followed by a test of free recall. The experimenter predicted that free recall would be higher in the no-noise condition. Thus, there was a directional hypothesis.

The sign test is ideal to use if the data are ordinal as it analyzes at a very basic level, e.g., in a race it can tell you that "John beat Peter." It can also be used with interval or ratio data, but as it only gives a crude analysis, these data would be better applied to the Wilcoxon test, which can give a more sophisticated analysis, e.g., "John beat Peter by 2 seconds."

In order to calculate the sign test it is necessary first of all to draw up a table like the one in the example, in which each participant's scores in Condition A and in Condition B are recorded. Each participant whose score in Condition A is greater than his or her score in Condition B is given a plus sign (+) in the sign column, and each participant whose score in Condition B is greater than his or her score in Condition A is given a minus sign (–) in the sign column. Each participant whose scores in both conditions are the same receives a 0 sign in the sign column, and are ignored

Sign test: A worked example

Experimental hypothesis: Free recall is better when learning takes place in the absence of noise than in its presence

Null hypothesis: Free recall is not affected by whether or not noise is present during learning

Participant	Condition A *(no noise)*	Condition B *(loud noise)*	Sign
1	12	8	+
2	10	10	0
3	7	8	−
4	12	11	+
5	8	3	+
6	10	10	0
7	13	7	+
8	8	9	−
9	14	10	+
10	11	9	+
11	15	12	+
12	11	10	+

Number of + signs = 8
Number of − signs = 2
Number of 0 signs = 2

Number of participants with differing scores (N) = 8 + 2 = 10
Number of participants with less-frequent sign (S) = 2

Question: Is the value of S in this example the same as or lower than the tabled value for S?

Table values

	5%
N = 10	S = 1

Conclusion: In this experiment the value of S is higher than the tabled value when N = 10. The null hypothesis (that noise has no effect on learning and memory) cannot be rejected.

in the subsequent calculations—they do not contribute to N (the number of paired scores), as they provide no evidence about effect direction.

In the example, there are eight plus signs, two minus signs, and two participants had the same scores in both conditions. If we ignore the two participants with the same scores in both conditions, this gives us N = 10. Now all we need to do is to work out the number of these 10 participants having the less frequently occurring sign; this value is known as S. In terms of our example, S = 2. We can refer to the relevant table (Appendix 2) with N = 10 and S = 2 and the statistical significance is the standard 5%. The obtained value for S must be the same as or lower than the value for S given in the table. The tabled value for a one-tailed test is 1. Thus, our obtained S value of 2 is not significant at the 5% level on a one-tailed test. We therefore conclude that we cannot reject the null hypothesis that noise has no effect on learning and memory.

Wilcoxon matched pairs signed ranks test

The Wilcoxon matched pairs signed ranks test can be used when a repeated measures or matched participants design has been used and the data are at least ordinal. This test or the sign test can be used if the data are ordinal, interval, or ratio. However, the Wilcoxon matched pairs signed ranks test uses more of the information obtained from a study, and so is usually a more sensitive and useful test than the sign test.

Wilcoxon matched pairs signed ranks test: A worked example

Experimental hypothesis: Free recall is better when learning takes place in the absence of noise than in its presence

Null hypothesis: Free recall is not affected by whether or not noise is present during learning

Participant	Condition A *(no noise)*	Condition B *(loud noise)*	Difference (d) *(A – B)*	Rank
1	12	8	4	7.5
2	10	10	0	–
3	7	8	−1	2.5
4	12	11	1	2.5
5	8	3	5	9
6	10	10	0	–
7	13	7	6	10
8	8	9	−1	2.5
9	14	10	4	7.5
10	11	9	2	5
11	15	12	3	6
12	11	10	1	2.5

Sum of positive ranks (7.5 + 2.5 + 9 + 10 + 7.5 + 5 + 6 + 2.5) = 50

Sum of negative ranks (2.5 + 2.5) = 5

Smaller value (5) + T

Number of participants who scored differently in condition A and B (N) = 10

Question: For the results to be significant, the value of T must be the same as, or less than, the tabled value.

Table values

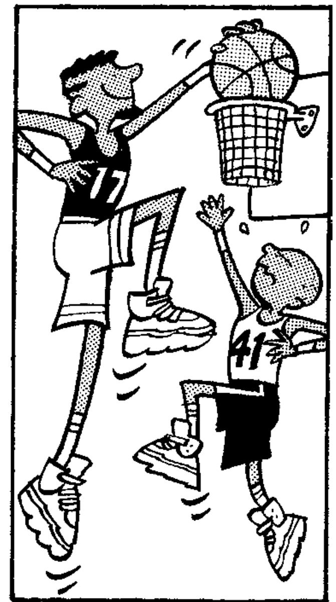
	5%	1%
N = 10	S = 1	5

Conclusion: In this experiment T is less than the tabled value at the 5% level and the same as the tabled value at the 1% level of significance, so the null hypothesis is rejected in favor of the experimental hypothesis.

The worked example uses the data from the sign test. The first step is to place all the data in a table in which each participant's two scores are in the same row. The second step is to subtract the Condition B score from the Condition A score for each participant to give the difference (d). The third step is to omit all the participants whose two scores are the same, i.e., d = 0. The fourth step is to rank all the difference scores obtained in the second step from 1 for the smallest difference, 2 for the second smallest difference, and so on. For this purpose, ignore the + and – signs, thus taking the absolute size of the difference. The fifth step is to add up the sum of the positive ranks (50 in the example) and separately to add up the sum of the negative ranks (5 in the example). The smaller of these values is T, which in this case is 5. The sixth step is to work out the number of participants whose two scores are not the same, i.e. d ≠ 0. In the example, N = 10.

The obtained value of T must be the same as, or less than, the tabled value (see Appendix 3) in order for the results to be significant. The tabled value for a one-tailed test and N = 10 is 11 at the 5% level of statistical significance, and it is 5 at the 1% level. Thus, the findings are significant at the 1% level on a one-tailed test. The null hypothesis is rejected in favor of the experimental hypothesis that free recall is better when learning takes place in the absence of noise than in its presence (p = .01). The presence of ties means that the tables are not completely accurate, but this does not matter provided that there are only a few ties.

You may be wondering how it is possible for the same data to produce a significant finding on a Wilcoxon matched pairs signed ranks test but not on a sign test. Does this indicate that statistics are useless? Not at all. The sign test is insensitive (or lacking in power) because it takes no account of the *size* of each individual's difference in free recall in the two conditions. It is because this information is made use of in the Wilcoxon matched pairs signed ranks test that a significant result was obtained using that test. Thus, the Wilcoxon matched pairs signed ranks test has more power than the sign test to detect differences between two conditions.



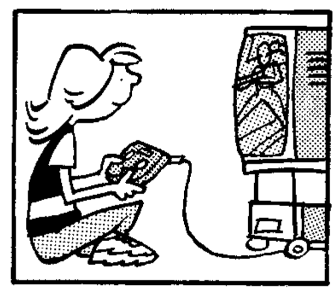
A positive correlation: The taller the player, the higher the score.

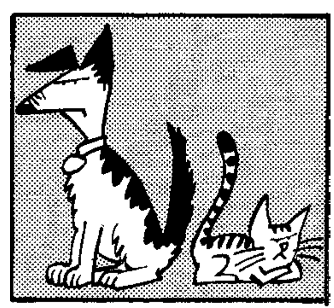
CORRELATIONAL STUDIES

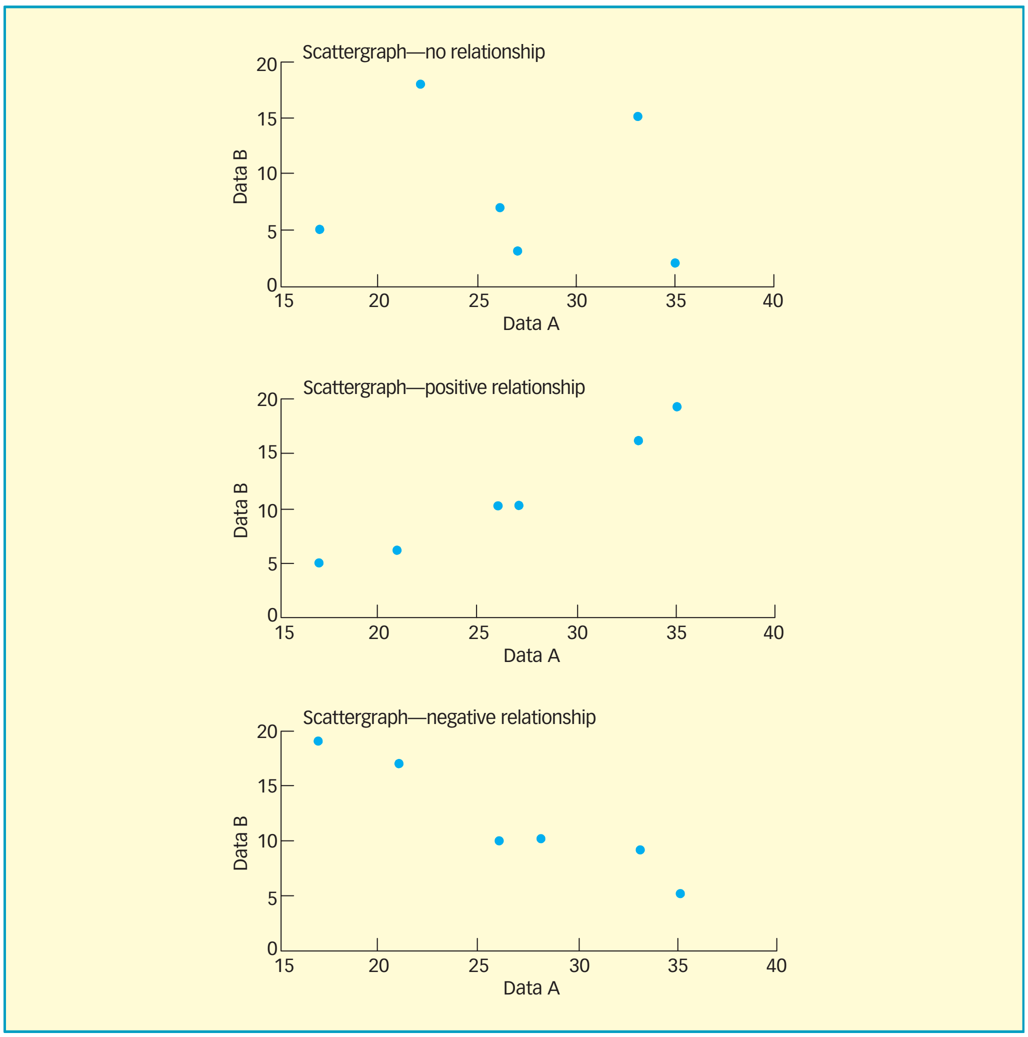
In the case of correlational studies, the data are in the form of two measures of behavior from each member of a single group of participants. What is often done is to present the data in the form of a **scattergraph** (also known as a scattergram). It is given this name because it shows the ways in which the scores of individuals are scattered.

Scattergraphs

Suppose that we have carried out a study on the relationship between the amount of television violence seen and the amount of aggressive behavior displayed. We could have a scale of the amount of television violence seen on the horizontal axis, and a scale of the amount of aggressive behavior on the vertical axis. We could then put a dot for each participant indicating where he or she falls on these two dimensions. For example,


A negative correlation: The more time spent playing computer games, the less time spent studying.


No correlation: Where there is no relationship, variables are uncorrelated.



Key Term

Scattergraph: a two-dimensional representation of all the participants' scores in a correlational study; also known as a scattergram.

suppose that one individual watched 17 hours of television and obtained a score of 8 for aggressive behavior. We would put a cross at the point where the invisible vertical line from the 17 meets the invisible horizontal line from the 8.

How do we interpret the information contained in a scattergraph? If there is a positive relationship between watching violence and aggression, then the dots should tend to form a pattern going from the bottom left of the scattergraph to the top right. If there is no relationship between the two variables, then the dots should be distributed in a fairly random way within the scattergraph. If there is a negative relationship between the two variables, then the dots will form a pattern going from the top left to the bottom right. In the present example, this would mean that watching a lot of television violence was associated with a *low* level of aggression.

As we will see shortly, the strength of a correlation between two variables can be assessed statistically by Spearman's rho. What, then, is the value of a scattergraph? Spearman's rho is limited in that it sometimes indicates that there is no relationship between two variables even when there is. For example, Spearman's rho would not reveal the existence of a strong curvilinear (bow-shaped) relationship between two variables, but this would be immediately obvious in a scattergraph.

Spearman's rho

Suppose that we have scores on two variables from each of our participants, and we want to see whether there is an association or correlation between the two sets of scores. This can be done by using a test known as Spearman's rho, provided that the data are at least ordinal. Spearman's rho or r_s indicates the strength of the association. If r_s is $+1.0$, then there is a perfect positive correlation between the two variables. If r_s is -1.0, then there is a perfect negative correlation between the two variables. If r_s is 0.0, then there is generally no relationship between the two variables. The working of this test is shown in the example opposite.

An experimenter collects information about the amount of television violence seen in the past month and about the amount of aggressive behavior exhibited in the past month from 12 participants. She predicts that there will be a positive association between these two variables, that is, those participants who have seen the most television violence (variable A) will tend to be the most aggressive (variable B). In other words, there is a directional hypothesis.

The first step is to draw up a table in which each participant's scores for the two variables are placed in the same row.

The second step is to rank all the scores for variable A. A rank of 1 is assigned to the smallest score, a rank of 2 to the second smallest score, and so on up to 12. What do we do if there are tied scores? In the example, participants 9 and 12 had the same score for variable A. The ranks that they are competing for are ranks 5 and 6. What is done is to take the average or mean of the ranks at issue: $(5 + 6)/2 = 5.5$.

The third step is to rank all the scores for variable B, with a rank of 1 being assigned to the smallest score. Participants 6, 7, 9, and 11 are all tied, with the ranks at issue being ranks 4, 5, 6, and 7. The mean rank at issue is $(4 + 5 + 6 + 7)/4 = 5.5$.

The fourth step is to calculate the difference between the two ranks obtained by each individual, with the rank for variable B being subtracted from the rank for variable A. This produces 12 difference (d) scores.

The fifth step is to square all of the d scores obtained in the fourth step. This produces 12 squared difference (d^2) scores.

The sixth step is to add up all of the d^2 scores in order to obtain the sum of the squared difference scores. This is known as Σd^2, and comes to 30 in the example.

The seventh step is to work out the number of participants. In the example, the number of participants (N) is 12.

The eighth step is to calculate rho from the following formula:

$$\text{rho} = 1 - \frac{(\Sigma d^2 \times 6)}{N(N^2 - 1)}$$

In the example, this becomes

$$1 - \frac{(30 \times 6)}{12(143)} = 1 - 0.105 = + 0.895$$

The ninth and final step is to work out the significance of the value of rho by referring the result to the table (see Appendix 4). The obtained value must be as great as, or greater than, the tabled value. The tabled value for a one-tailed test with N = 12 is +0.503 at the .05 level, it is +0.671 at the .01 level, and it is +0.727 at the .005 level. Thus, it can be concluded that the null hypothesis should be rejected in favor of the experimental hypothesis that there is a positive correlation between the amount of television violence watched and aggressive behavior (p = .005).

An important point about Spearman's rho is that the statistical significance of the obtained value of rho depends very heavily on the number of participants. For example, the tabled value for significance at the .05 level on a one-tailed test is +0.564 if there are 10 participants. However, it is only +0.306 if there are 30 participants. In practical terms,

A worked example of a test for correlation between two variables using Spearman's rho

Experimental hypothesis: There is a positive association between amount of television violence watched and aggressive behavior

Null hypothesis: There is no association between amount of television violence watched and aggressive behavior

Participants	TV violence seen (hours)	Aggressive behavior (out of 10)	Rank A	Rank B	Difference d	d^2
1	17	8	7.5	9	−1.50	2.25
2	6	3	2	2	0.00	0.00
3	23	9	10	10.5	−0.50	0.25
4	17	7	7.5	8	−0.50	0.25
5	2	2	1	1	0.00	0.00
6	20	6	9	5.5	+3.50	12.25
7	12	6	4	5.5	0.00	2.25
8	31	10	12	12	0.00	0.00
9	14	6	5.5	5.5	+0.50	0.00
10	26	9	10.5	10.5	+0.50	0.25
11	9	6	5.5	5.5	−2.50	6.52
12	14	4	3	3	+2.50	6.25

Sum of squared difference scores (Σd^2) = 30
Number of participants (N) = 12

Formula: $\text{rho} = 1 - \frac{(\Sigma d^2 \times 6)}{N(N^2 - 1)}$

Example: $1 - \frac{(30 \times 6)}{12(143)} = 1 - 0.105 = +0.895$

Is the value of rho (+0.895) as great as or greater than the tabled value?

Table values

	.05 level	.01 level	.005 level
N = 12	+0.503	+0.671	+0.727

Conclusion: Null hypothesis rejected in favor of experimental hypothesis, i.e., there is a positive correlation between the amount of television violence watched and aggressive behavior (p = .005).

this means that it is very hard to obtain a significant correlation with Spearman's rho if the number of participants is low.

TEST OF ASSOCIATION

The **chi-squared test** is a test of association. It is used when we have nominal data in the form of frequencies, and when each and every observation is independent of all the other observations. For example, suppose that we are interested in the association between eating patterns and cholesterol level. We could divide people into those having a healthy diet with relatively little fat and those having an unhealthy diet. We could also divide them into those having a fairly high level of cholesterol and those having a low level of cholesterol. In essence, the chi-squared test tells us whether membership of a given category on one dimension (e.g., unhealthy diet) is associated with membership of a given category on the other dimension (e.g., high cholesterol level).

In the worked example opposite, we will assume that we have data from 186 individuals with an unhealthy diet, and from 128 individuals with a healthy diet. Of those with an unhealthy diet, 116 have a high cholesterol level and 70 have a low cholesterol level. Of those with a healthy diet, 41 have a high cholesterol level and 87 have a low cholesterol level. Our experimental hypothesis is that there is an association between healthiness of diet and low cholesterol level.

The first step is to arrange the frequency data in a 2 ×2 "contingency table" as in the worked example, with the row and column totals included. The second step is to work out what the four frequencies would be if there were no association at all between diet and cholesterol levels. The expected frequency (by chance alone) in each case is given by the following formula:

$$\text{expected frequency} = \frac{\text{row total} \times \text{column total}}{\text{overall total}}$$

For example, the expected frequency for the number of participants having a healthy diet and high cholesterol is 157 × 128 divided by 314, which comes to 64. The four expected frequencies (those expected by chance alone) are also shown in the table.

The third step is to apply the following formula to the observed (O) and expected (E) frequencies in each of the four categories:

$$\frac{\left(|O - E| - \frac{1}{2}\right)^2}{E}$$

In the formula, $|O - E|$ means that the difference between the observed and the expected frequency should be taken, and it should then have a + sign put in front of it regardless of the direction of the difference. The correction factor (i.e., $-\frac{1}{2}$) is only used when there are two rows and two columns.

The fourth step is to add together the four values obtained in the third step in order to provide the chi-squared statistic or χ^2. This is 7.91 + 5.44 + 7.91 + 5.44 = 26.70.

The fifth step is to calculate the number of "degrees of freedom" (df). This is given by (the number of rows − 1) × (the number of columns − 1). For this we need to refer back to the contingency table. In the example, this is 1 × 1 = 1. Why is there 1 degree of freedom? Once we know the row and column totals, then only one of the four observed values is free to vary. Thus, for example, knowing that the row totals are 157 and 157, the column totals are 128 and 186, and the number of participants having a healthy diet and high cholesterol is 41, we can complete the entire table. In other words, the number of degrees of freedom corresponds to the number of values that are free to vary.

The sixth step is to compare the tabled values in Appendix 5 with chi-squared = 26.70 and one degree of freedom. The observed value needs to be the same as, or greater than, the tabled value for a two-tailed test in order for the results to be significant.

The tabled value for a two-tailed test with df = 1 is 3.84 at the .05 level, 5.41 at the .02 level, and 10.83 at the .001 level. Thus, we can reject the null hypothesis, and conclude that there is an association between healthiness of diet and cholesterol level (p = .001).

Key Term

Chi-squared test: a test of association that is used with nominal data in the form of frequencies.

Test of association: Chi-squared test, a worked example

Experimental hypothesis: There is an association between healthiness of diet and low cholesterol level
Null hypothesis: There is no association between healthiness of diet and low cholesterol level

Contingency table:

	Healthy diet	Unhealthy diet	Row total
High cholesterol	41	116	157
Low cholesterol	87	70	157
Column total	128	186	314

Expected frequency if there were no association:

Formula: $\frac{\text{row total} \times \text{column total}}{\text{expected frequency}} = \text{overall total}$

	Healthy diet	Unhealthy diet	Row total
High cholesterol	64	93	157
Low cholesterol	64	93	157
Column total	128	186	314

Calculating chi-squared statistic (χ^2):

Formula: $\chi^2 = \Sigma \frac{\left(|O - E| - \frac{1}{2}\right)^2}{E} = 26.7$

Note: Correction factor $\left(-\frac{1}{2}\right)$ is only used where there are two rows and two columns

Category	Observed	Expected	$\lvert O - E\rvert$	$\frac{\left(\lvert O - E\rvert - \frac{1}{2}\right)^2}{E}$
Healthy, high cholesterol	41	64	23	7.91
Unhealthy, high cholesterol	116	93	23	5.44
Healthy, low cholesterol	87	64	23	7.91
Unhealthy, low cholesterol	70	93	23	5.44
				26.70

Calculating degrees of freedom:

Formula: (no. of rows − 1) × (no. of columns − 1) = degrees of freedom (2 − 1) × (2 − 1) = 1

Compare chi-squared statistic with tabled values:

Table values

	.05 level	.01 level	.001 level
df = 1	3.84	6.64	10.83

Question: Is the observed chi-squared value of 26.70 and one degree of freedom the same as or greater than the tabled value?

Conclusion: The chi-squared value is greater than the tabled value, so the null hypothesis can be rejected, and the experimental hypothesis, that there is an association between healthiness of diet and cholesterol level, accepted.

It is easy to use the chi-squared test wrongly. According to Robson (1994), “There are probably more inappropriate and incorrect uses of the chi-square test than of all the other statistical tests put together.” In order to avoid using the chi-squared test wrongly, it is important to make use of the following rules:

- Ensure that every observation is independent of every other observation; in other words, each individual should be counted once and in only *one* category.

- Make sure that each observation is included in the appropriate category; it is not permitted to omit some of the observations (e.g., those from individuals with intermediate levels of cholesterol).
- The total sample should exceed 20; otherwise, the chi-squared test as described here is not applicable. More precisely, the minimum expected frequency should be at least 5 in every category.
- The significance level of a chi-squared test is nearly always assessed by consulting the two-tailed values in the Appendix table regardless of whether the hypothesis is directional or nondirectional. The one exception is if you have one variable divided into two categories and a directional hypothesis. Why is the chi-squared so unusual in typically requiring you to use two-tailed values? The reason is that *any* differences between expected and observed values (whether predicted or not) increase the obtained value.
- Remember that showing there is an association is not the same as showing that there is a causal effect; for example, the association between a healthy diet and low cholesterol does not demonstrate that a healthy diet *causes* low cholesterol.

ISSUES OF EXPERIMENTAL AND ECOLOGICAL VALIDITY

Assume that you have carried out a study, and then analyzed it using a statistical test. The results were statistically significant, so you are able to reject the null hypothesis in favor of the experimental hypothesis. When deciding how to interpret your findings, you need to take account of issues relating to experimental and ecological validity. **Experimental validity** is based on the extent to which a given finding is genuine, and is a result of the independent variable that was manipulated. In other words, it is essentially the same as internal validity, which is discussed in Chapter 24. In contrast, **ecological validity** refers to the extent to which research findings can be generalized to a range of real-world settings. It is clearly desirable for a study to possess both of these forms of validity.

EXPERIMENTAL VALIDITY

How can we assess the experimental or internal validity of the findings from a study? The key point is made in Chapter 24: We can only have confidence that the independent variable produced the observed effects on behavior or the dependent variable provided that all of the principles of experimental design were followed. These principles include the standardization of instructions and procedures; counterbalancing; randomization; and the avoidance of confounding variables, experimenter effects, demand characteristics, and participant reactivity.

We can check these by asking various questions about a study, including the following:

- Were there any variables (other than the independent variable) that varied systematically between conditions?
- Did all the participants receive the same standardized instructions?
- Were the participants allocated at random to the conditions?
- Did the experimenter influence the performance of the participants by his or her expectations or biases?
- Were the participants influenced by any demand characteristics of the situation?
- If the participants knew they were being observed, did this influence their behavior?

Probably the most convincing evidence that a study possesses good experimental validity is if its findings can be repeated or replicated in other studies. Why is that so? Suppose, for example, that we obtain significant findings in one study because we failed to allocate our participants at random to conditions. Anyone else carrying out the same study, but allocating the participants at random, would be very unlikely to repeat the findings of our study.

ECOLOGICAL VALIDITY

As Coolican (1994) pointed out, the term ecological validity has been used in various ways. It is sometimes used to refer to the extent to which a given study was carried out

Key Terms

Experimental validity: the extent to which a finding is genuine, and is a result of the **independent variable** being manipulated.

Ecological validity: the extent to which the findings of laboratory studies are applicable to everyday settings and generalize to other locations, times, and measures.

Case Study: *Criticism of Intelligence Testing*

Gould's (1982) study included criticism of intelligence testing based on the methodological and theoretical problems experienced when these tests are used. Gould suggested that many IQ tests contain errors of validity. They have design flaws in relation to the wording used, which is often based on cultural definitions of meaning. Lack of access to the relevant cultural interpretations would disadvantage certain groups and individuals. For example, the Yerkes Tests of Intelligence were based on American culture and cultural knowledge, so that immigrants' performance was almost always poorer than that of the native groups. Gould also emphasized the fact that the procedures used were flawed, especially during the testing of black participants.

Interpretation of findings from the use of Yerkes tests ignored the role of experience and education in IQ, and focused on the role of heredity. The research evidence was used to support racist social policy, which restricted work opportunities for ethnic groups within society and denied many the right to seek political refuge in America.

in a naturalistic or real-world setting rather than in an artificial one. However, as was mentioned earlier, it is probably more useful to regard ecological validity as referring to the extent to which a study generalizes to various real-world settings. Bracht and Glass (1968) put forward a definition of ecological validity along those lines. According to them, the findings of ecologically valid studies generalize to other locations or places, to other times, and to other measures. Thus, the notion of ecological validity closely resembles that of external validity (see Chapter 24), except that external validity also includes generalization to other populations.

How do we know whether the findings of a study possess ecological validity? The only conclusive way of answering that question is by carrying out a series of studies in different locations, at different times, and using different measures. Following that approach is generally very costly in terms of time and effort.

It is often possible to obtain some idea of the ecological validity of a study by asking yourself whether there are important differences between the way in which a study has been conducted and what happens in the real world. For example, consider research on eyewitness testimony (see Chapter 8). The participants in most laboratory studies of eyewitness testimony have been asked to pay close attention to a series of slides or a video depicting some incident, after which they are asked various questions. The ecological validity of such studies is put in danger for a number of reasons. The participants have their attention directed to the incident, whereas eyewitnesses to a crime or other incident may fail to pay much attention to it. In addition, eyewitnesses are often very frightened and concerned about their own safety, whereas the participants in a laboratory study are not.

It may seem reasonable to argue that we could ensure ecological validity by taking research out of the laboratory and into the real world. However, powerful arguments against doing that with memory research were put forward by Banaji and Crowder (1989):

> *Imagine astronomy being conducted with only the naked eye, biology without tissue cultures . . . or chemistry without test tubes! The everyday world is full of principles from these sciences in action, but do we really think their data bases should have been those of everyday applications? Of course not. Should the psychology of memory be any different? We think not.*

In sum, investigators should consider the issue of ecological validity seriously when interpreting their findings. They should try to identify the main ways in which the situation or situations in which their participants were placed differ

Ecological validity

The term ecological validity refers to the extent to which any study's findings can be generalized to other settings. Although many laboratory studies may lack ecological validity, so do some of those conducted in natural settings.

Consider Skinner's work on pigeons pecking at a disk to receive food pellets. Could the results of his study be generalized to explain how dog handlers train their dogs to seek out illegal drugs and explosives? Do the procedures for operant conditioning remain the same, i.e., the use of reinforcement to shape behavior?

Imagine you are an observer watching birds in their natural environment, collecting data on how the parents are caring for their offspring. You disturb the parent birds by making too much noise, and they abandon their nesting site. Would your research have ecological validity because it was carried out in the natural environment? Could you generalize your findings to other settings?

from those of everyday life. They should also take account of the desirability of measuring behavior that is representative of behaviors that occur naturally. At the very least, they should interpret their findings cautiously if there are several major differences. Finally, they should discuss relevant published research that indicates the likely impact of these differences on participants' behavior.

WRITING UP A PRACTICAL

Practicals in psychology are written up in a standard way. Thus, your write-ups need to be organized in a certain fashion. Initially, this may seem difficult. However, it has the great advantage that this organization makes it easy for someone reading your write-ups to know where to look to find information about the type of participants used, the statistical analyses, and so on. The details of how to produce a write-up differ slightly depending on whether it is based on an experimental or a nonexperimental design. However, the general approach is exactly the same, and the essence of that approach is given later. The sections are arranged in the order they should appear in your write-ups. It is essential to refer to coursework assessment criteria issued by the relevant examination board.

Finally, be sure to write in a formal way. For example, write "It was decided to study the effects of attention on learning" rather than, "I decided to study the effects of attention on learning."

Title

This should give a short indication of the nature of your study. In the case of an experimental study, it might well refer to the independent and dependent variables. A non-experimental study would include reference to the qualitative nature of the investigation.

Abstract

This should provide a brief account of the purpose of the study, the key aspects of the design, the use of statistics, and the key findings and their interpretation.

Introduction

This should start with an account of the main concepts and background literature relevant to your study. It should then move on to a consideration of previous work that is of *direct* relevance to your study. Avoid describing several studies that are only loosely related to your study.

Aims and hypotheses

The aims refer to the general context of the research and indicate why you selected the hypotheses to be tested. This should be followed by specifying the hypotheses. If it is an experimental study, the hypotheses should refer to the relevant independent and dependent variables.

Method

Design. Here you should indicate the number of groups, the use of an independent samples or repeated measures design (if applicable), the nature of the independent and dependent variables (if any), the experimental hypothesis, and the null hypothesis. You should also indicate any attempts made to control the situation effectively so as to produce an effective design.

Participants. The number of participants should be given together with relevant information about them (e.g., age, gender, educational background). You should indicate how they were selected for your study and, in the case of an experiment, refer to the way in which they were allocated to conditions.

Apparatus and materials. There should be a brief description of any apparatus used in the study, together with an account of any stimuli presented to the participants (e.g., 20 common 5-letter nouns). The stimuli should be referred to in a numbered section in an appendix where they can be examined in detail.

Procedure. The sequence of events experienced by the participants, including any instructions given to them, should be indicated here. Standardized instructions may be given in detail in an appendix.

Results

It is generally useful to restate the aims of the study and to indicate the independent and dependent variables in the case of an experiment.

Also, it is desirable to provide a summary table of the performance of participants. Tables of central tendency and standard deviation are usually informative ways of getting an overall "picture" of results. A bar chart or some other suitable figure may provide ready visual access to a large body of information.

- Make sure that tables and figures are clearly labeled.
- Make sure that raw data appear in a numbered section of the appendix.

Statistical test and level of significance. Start by indicating which hypothesis has been tested by any given statistical test. The test that has been applied to the data should be indicated, together with the justification for the selection of the test. Also there should be reference to the level of statistical significance that was achieved with respect to the test statistic chosen. Make sure you indicate whether a one-tailed or a two-tailed test was used, and relate your findings to the experimental and null hypotheses.

Discussion

The discussion should start by considering your findings, especially with respect to the results of the statistical test or tests. Be as precise as possible in terms of what your findings show (and do not show!). You may wish to comment on individual results that were inconsistent with the rest of the participants' data.

The next part of this section should consist of how your findings relate to previous findings referred to in the introduction. Ask yourself if they support or refute existing theories or approaches and how you might account for the behavior of the participants.

Next, identify any weaknesses in your study, and indicate how they could be eliminated in a subsequent study. For example, there may have been ethical issues that arose during the investigation which only became apparent after you had started.

Finally, consider whether there are interesting ways in which your study could be extended to provide more information about the phenomenon you have been investigating. This is a very satisfactory section to deal with because your imagination can take over, producing ideal studies unencumbered by the necessity to go and find participants! Always remember, though, that possible extension studies should be relevant and the likely outcome to them should be mentioned.

References

Full information about any references you have referred to in the write-up should be provided here. Textbooks (including this one) typically have a reference section set out in conventional style and you should refer to it.

Chapter Summary

Qualitative analysis of data

- Qualitative research is concerned with the experiences of the participants, and with the meanings they attach to themselves and their lives. Investigators using interviews, case studies, or observations often (but not always) make use of qualitative data. A key principle of qualitative analysis is that theoretical understanding emerges from the data, and is not imposed by the researcher. Qualitative researchers typically categorize the data after taking account of all of the data and of the participants' own categories. Findings based on qualitative data tend to be unreliable and hard to replicate.

Interpretation of interviews, case studies, and observations

- It can be hard to interpret the information obtained from interviews because of social desirability bias, complex interactional processes, and the self-fulfilling prophecy. The greatest danger with case studies is drawing very general conclusions from a single atypical individual. Case studies can suggest hypotheses, which can then be tested with larger groups. The findings of observational studies are often difficult to interpret, because it is not clear *why* the participants are behaving as they are. In addition, the participants in observational studies may not be representative.

Content analysis

- Content analysis has been used as a method for analyzing messages in the media as well as communications that participants have been asked to produce, such as diaries. The first step is the construction of coding units into which the selected information can be categorized. Coders may be asked to provide ratings or rankings as well as to categorize.

Quantitative analysis: Descriptive statistics

- When we have obtained scores from a group of participants, we can summarize our data by working out a measure of central tendency and a measure of dispersion or spread of scores around the central tendency. The mean is the most generally useful measure of central tendency, but other measures include the median and mode. The standard deviation is the most useful measure of dispersion. Other measures include the range and the variation ratio.

Data presentation

- Summary data from a study can be presented in the form of a figure, so that it is easy to observe general trends. Among the possible ways of presenting the data in a figure are the following: frequency polygon; histogram; and bar chart. Frequency polygons and histograms are used when the scores can be ordered from low to high, whereas bar charts are used when the scores are in the form of categories.

Statistical tests

- If the experimental hypothesis predicts the direction of effects, then a one-tailed test should be used. Otherwise, a two-tailed test should be used. There are four types of data of increasing levels of precision as follows: nominal; ordinal; interval; and ratio. Psychologists generally use the 5% level of statistical significance. This produces fairly small probabilities of incorrectly rejecting the null hypothesis in favor of the experimental hypothesis (Type I error) or of incorrectly retaining the null hypothesis (Type II error). A test of difference is used when data are obtained from a study in which an independent variable was manipulated to observe its effects. The Mann-Whitney U test is the appropriate test of difference if an independent design was used. The sign test can be used when a repeated measures or matched participants design was used and the data are nominal or ordinal. The same is true of the Wilcoxon matched pairs signed ranks test, except that the data must be at least ordinal.
- The data from correlational studies are in the form of scores on two response variables from every participant. These data can be presented in the form of a scattergraph or scattergram. The correlation between two sets of scores can be calculated by means of Spearman's rho test, provided that the data are at least ordinal.
- The chi-squared test is a test of association. It is used when we have nominal data in the form of frequencies, and when each and every observation is independent of all the other observations. The test is nearly always two-tailed. All the expected frequencies should be 5 or more. Finding an association is not the same as showing the existence of a causal effect.

Issues of experimental and ecological validity

- Experimental validity is based on the extent to which a given finding is genuine, and is a result of the independent variable that was manipulated. A study is most likely to be high in experimental validity when all the principles of experimental design (e.g., randomization; standardization) have been followed. Replication provides some assurance that experimental validity is high. Ecological validity refers to the extent to which the findings of a study generalize to other locations, times, and measures. The ecological validity of a study is best assessed by carrying out a range of further studies using different locations, times, and measures.

Further Reading

- Banister, P., Burman, E., Parker, I., Taylor, M., & Tindall, C. (1994). *Qualitative methods in psychology: A research guide*. This gives extensive coverage of the main types of qualitative analysis.
- Coolican, H. (1999). *Research methods and statistics in psychology* (3rd ed.). London: Hodder & Stoughton. This textbook gives detailed but user-friendly coverage of the topics discussed in this chapter.
- Coolican, H. (2004). *Research methods and statistics in psychology* (4th ed.). London: Hodder & Stoughton. This book gives an excellent account of statistics as well as of research methods.

Appendices

Contents

Research Methods: Appendices

In order to use the statistical tables on the following pages, you first need to decide whether:

1. Your data are in numerical form, in which case they are suitable for quantitative analysis; otherwise, use qualitative analysis.
2. You have obtained nominal, ordinal, interval, or ratio data.
3. Your data show a difference between the two conditions (the experimental hypothesis) or not (the null hypothesis).
4. You can use parametric tests (i.e., if data are interval or ratio, normally distributed, and the variances in the two conditions are similar); otherwise nonparametric tests can be used. Nonparametric tests can be used in nearly all cases, and it is the most useful of these that are described in this book.

Once you have obtained your results, you can construct a table of frequencies, and decide which type of chart or graph you wish to use in order to present your data graphically in the clearest way possible.

The next step to take is to analyze your data, as follows:

1. Calculate measures of central tendency: mean, median, and mode.
2. Calculate measures of dispersion: range, interquartile range, variation ratio, and standard deviation.

You will then need to apply further statistical analysis using the statistical tests described in Chapter 25. Please refer to the worked examples for each of these and follow the step-by-step instructions in the main text.

HOW TO DECIDE WHICH TEST TO USE

The main purpose of these tests is to decide the probability of the null hypothesis being correct, and to evaluate its significance. Each test involves calculating your observed value from your results, and then looking up the critical value in a table of values, to see whether your value is greater than, equal to, or less than the critical value. Use the appropriate column or table, depending on (a) whether you used a one- or two-tailed test and (b) which level of significance or probability (p) you wish to check. If p is less than or equal to .05 or 5%, which is the standard probability of significance used by psychologists, the null hypothesis is rejected in favor of the experimental hypothesis. To see whether the findings are highly significant, look at whether the null hypothesis still holds true at p = .01, or 1%, or even p = .001, or .1%.

If your experimental hypothesis is directional (i.e., you predicted the direction of any effects), you need to use a one-tailed test; otherwise you have a nondirectional hypothesis, in which case you need to use a two-tailed test.

If the design of your test of difference is independent, as long as the data are ordinal or interval, the Mann-Whitney U test can be used. If you have used a repeated measures or matched participants design, the sign test can be used, as long as the data are ordinal; or if the data are interval or ratio, the Wilcoxon matched pairs signed ranks test can be used. The latter is more sensitive than the sign test. The sign test provides us with a crude analysis, which is sufficient when data are ordinal, but when actual values are obtained (interval or ratio data) the Wilcoxon test will provide a more sophisticated analysis. Therefore, although it is possible to use the sign test for interval or ratio data, it would be best to limit its use to analysis of ordinal data.

If you manipulated the independent variable (some aspect of the situation), you need to use a test of difference (such as the Mann-Whitney U test, the sign test or the Wilcoxon matched pairs signed ranks test); otherwise, you need to use a test of correlation (such as Spearman's rho test, as long as the data are ordinal, interval, or ratio) or a test of association (such as the chi-squared test, as long as the data are nominal).

HOW TO USE THE TABLES

Mann-Whitney U test
Appendix 1, pages 620–621

In the Mann-Whitney U test, use the smaller value of U and U′ to look up the critical value of U for a one- or two-tailed test, as appropriate, at .05, initially (bottom table, page 621). If the tabled value is equal to or less than your value at that level, the null hypothesis is retained; if it is greater than your value, it is rejected and your experimental hypothesis is proved.

Sign test
Appendix 2, page 622

In the sign test, look up the critical value of S for a one- or two-tailed test, as appropriate, for N, the number of participants with differing scores, at .05, initially. If the tabled value is equal to or less than your value at that level, the null hypothesis is retained; if it is greater than your value, it is rejected and your experimental hypothesis is proved.

Wilcoxon test
Appendix 3, page 623

In the Wilcoxon test, look up the critical value of T for a one- or two-tailed test, as appropriate, for N, the number of participants with differing scores, at .05, initially. If the tabled value is equal to or less than your value at that level, the null hypothesis is retained; if it is greater than your value, it is rejected and your experimental hypothesis is proved.

Spearman's rho test
Appendix 4, page 624

In Spearman's rho test, look up the critical value of r_S for a one- or two-tailed test, as appropriate, for N, the number of participants, at .05, initially. If the tabled value is greater than or equal to your value at that level, the null hypothesis is retained; if it is less than your value, it is rejected and your experimental hypothesis is proved.

Chi-squared test
Appendix 5, page 625

In the chi-squared test, look up the critical value of chi-squared (also shown as χ^2) for a two-tailed test for df, the degrees of freedom, at .05 initially. If the tabled value is greater than or equal to your value at that level, the null hypothesis is retained; if it is less than your value, it is rejected and your experimental hypothesis is proved.

TIPS

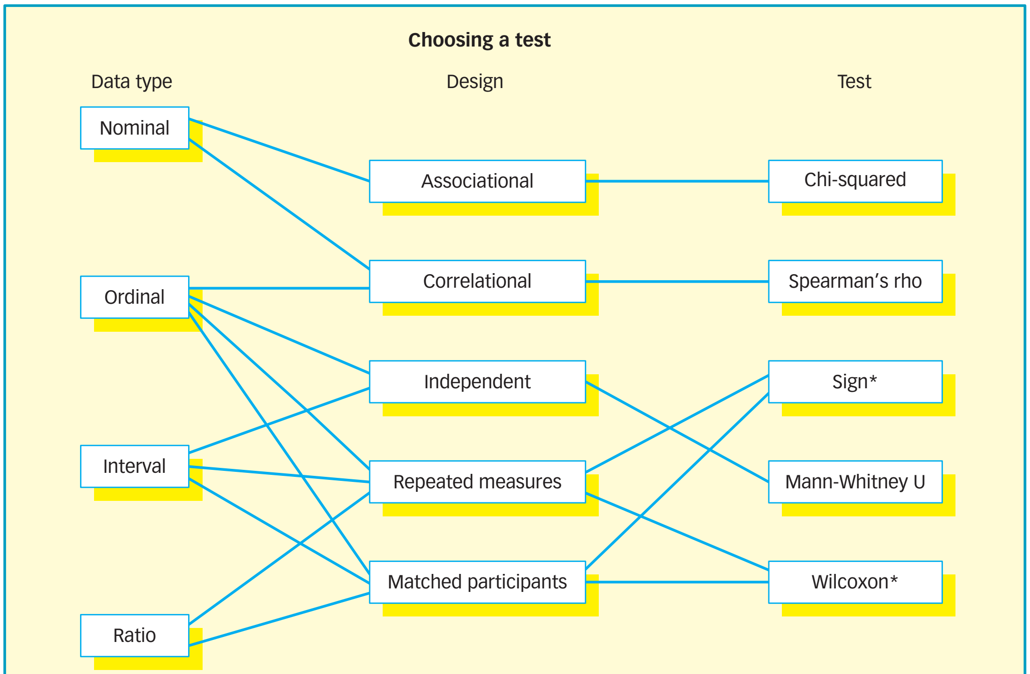
Remember that decisions based on statistical tests are open to error, but if you follow the standard procedures outlined in Chapter 25 the potential for errors can be minimized. Try to be as unbiased as possible, and try not to assume too much about the results in advance.

Ensure that you have not made errors of either Type I, which can be reduced by using a greater level of significance (e.g., $p = .01$, or 1%, or even $p = .001$, or .1%), or Type II, which can be reduced by using a lesser level of significance (e.g., $p = .10$, or 10%).

In the Mann-Whitney U test, remember that ties are possible—this reduces the accuracy, but has only a small effect unless there are several ties.

In the chi-squared test, do follow the rules on pages 609–610 of Chapter 25 to avoid incorrect use of this test.

The tests described in Chapter 25 provide different levels of analysis, and they require a particular type of data. The following chart outlines the tests that can be used for different data types and experimental designs. Please note that this chart deals only with the statistical tests described in Chapter 25.



*Wilcoxon and sign tests can both be used, but the Wilcoxon is preferable in all cases except when the data are ordinal, when the sign test must be used.

APPENDIX 1: MANN-WHITNEY U TEST

Critical values of U for a one-tailed test at .005; two-tailed test at .01*

	N_A																			
N_B	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
3	—	—	—	—	—	—	—	—	0	0	0	1	1	1	2	2	2	2	3	3
4	—	—	—	—	—	0	0	1	1	2	2	3	3	4	5	5	6	6	7	8
5	—	—	—	—	0	1	1	2	3	4	5	6	7	7	8	9	10	11	12	13
6	—	—	—	0	1	2	3	4	5	6	7	9	10	11	12	13	15	16	17	18
7	—	—	—	0	1	3	4	6	7	9	10	12	13	15	16	18	19	21	22	24
8	—	—	—	1	2	4	6	7	9	11	13	15	17	18	20	22	24	26	28	30
9	—	—	0	1	3	5	7	9	11	13	16	18	20	22	24	27	29	31	33	36
10	—	—	0	2	4	6	9	11	13	16	18	21	24	26	29	31	34	37	39	42
11	—	—	0	2	5	7	10	13	16	18	21	24	27	30	33	36	39	42	45	48
12	—	—	1	3	6	9	12	15	18	21	24	27	31	34	37	41	44	47	51	54
13	—	—	1	3	7	10	13	17	20	24	27	31	34	38	42	45	49	53	56	60
14	—	—	1	4	7	11	15	18	22	26	30	34	38	42	46	50	54	58	63	67
15	—	—	2	5	8	12	16	20	24	29	33	37	42	46	51	55	60	64	69	73
16	—	—	2	5	9	13	18	22	27	31	36	41	45	50	55	60	65	70	74	79
17	—	—	2	6	10	15	19	24	29	34	39	44	49	54	60	65	70	75	81	86
18	—	—	2	6	11	16	21	26	31	37	42	47	53	58	64	70	75	81	87	92
19	—	0	3	7	12	17	22	28	33	39	45	51	56	63	69	74	81	87	93	99
20	—	0	3	8	13	18	24	30	36	42	48	54	60	67	73	79	86	92	99	105

*Dashes in the body of the table indicate that no decision is possible at the stated level of significance.
For any N_A and N_B the observed value of U is significant at a given level of significance if it is *equal* to or *less* than the critical values shown.

Source: R. Runyon and A. Haber (1976). *Fundamentals of behavioural statistics* (3rd ed.). Reading, MA: McGraw Hill, Inc. With the kind permission of the publisher. Copyright © The McGraw-Hill Companies Inc.

Critical values of U for a one-tailed test at .01; two-tailed test at .02*

	N_A																			
N_B	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	0	0	0	0	0	0	1	1
3	—	—	—	—	—	—	—	0	0	1	1	1	2	2	2	3	3	4	4	5
4	—	—	—	—	0	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10
5	—	—	—	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6	—	—	—	1	2	3	4	6	7	8	9	11	12	13	15	16	18	19	20	22
7	—	—	0	1	3	4	6	7	9	11	12	14	16	17	19	21	23	24	26	28
8	—	—	0	2	4	6	7	9	11	13	15	17	20	22	24	26	28	30	32	34
9	—	—	1	3	5	7	9	11	14	16	18	21	23	26	28	31	33	36	38	40
10	—	—	1	3	6	8	11	13	16	19	22	24	27	30	33	36	38	41	44	47
11	—	—	1	4	7	9	12	15	18	22	25	28	31	34	37	41	44	47	50	53
12	—	—	2	5	8	11	14	17	21	24	28	31	35	38	42	46	49	53	56	60
13	—	0	2	5	9	12	16	20	23	27	31	35	39	43	47	51	55	59	63	67
14	—	0	2	6	10	13	17	22	26	30	34	38	43	47	51	56	60	65	69	73
15	—	0	3	7	11	15	19	24	28	33	37	42	47	51	56	61	66	70	75	80
16	—	0	3	7	12	16	21	26	31	36	41	46	51	56	61	66	71	76	82	87
17	—	0	4	8	13	18	23	28	33	38	44	49	55	60	66	71	77	82	88	93
18	—	0	4	9	14	19	24	30	36	41	47	53	59	65	70	76	82	88	94	100
19	—	1	4	9	15	20	26	32	38	44	50	56	63	69	75	82	88	94	101	107
20	—	1	5	10	16	22	28	34	40	47	53	60	67	73	80	87	93	100	107	114

*Dashes in the body of the table indicate that no decision is possible at the stated level of significance.
For any N_A and N_B the observed value of U is significant at a given level of significance if it is *equal* to or *less* than the critical values shown.

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Critical values of U for a one-tailed test at .025; two-tailed test at .05*

	N_A																			
N_B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	0	0	0	0	1	1	1	1	1	2	2	2	2
3	—	—	—	—	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4	—	—	—	0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	13
5	—	—	0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6	—	—	1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7	—	—	1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8	—	0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9	—	0	2	4	7	10	12	15	17	20	23	26	28	31	34	37	39	42	45	48
10	—	0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11	—	0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12	—	1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13	—	1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14	—	1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	67	74	78	83
15	—	1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16	—	1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17	—	2	6	11	17	22	28	34	39	45	51	57	63	67	75	81	87	93	99	105
18	—	2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19	—	2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20	—	2	8	13	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

*Dashes in the body of the table indicate that no decision is possible at the stated level of significance.
For any N_A and N_B the observed value of U is significant at a given level of significance if it is *equal* to or *less* than the critical values shown.

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Critical values of U for a one-tailed test at .05; two-tailed test at .10*

	N_A																			
N_B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
2	—	—	—	—	0	0	0	1	1	1	1	2	2	2	3	3	3	4	4	4
3	—	—	0	0	1	2	2	3	3	4	5	5	6	7	7	8	9	9	10	11
4	—	—	0	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18
5	—	0	1	2	4	5	6	8	9	11	12	13	15	16	18	19	20	22	23	25
6	—	0	2	3	5	7	8	10	12	14	16	17	19	21	23	25	26	28	30	32
7	—	0	2	4	6	8	11	13	15	17	19	21	24	26	28	30	33	35	37	39
8	—	1	3	5	8	10	13	15	18	20	23	26	28	31	33	36	39	41	44	47
9	—	1	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
10	—	1	4	7	11	14	17	20	24	27	31	34	37	41	44	48	51	55	58	62
11	—	1	5	8	12	16	19	23	27	31	34	38	42	46	50	54	57	61	65	69
12	—	2	5	9	13	17	21	26	30	34	38	42	47	51	55	60	64	68	72	77
13	—	2	6	10	15	19	24	28	33	37	42	47	51	56	61	65	70	75	80	84
14	—	2	7	11	16	21	26	31	36	41	46	51	56	61	66	71	77	82	87	92
15	—	3	7	12	18	23	28	33	39	44	50	55	61	66	72	77	83	88	94	100
16	—	3	8	14	19	25	30	36	42	48	54	60	65	71	77	83	89	95	101	107
17	—	3	9	15	20	26	33	39	45	51	57	64	70	77	83	89	96	102	109	115
18	—	4	9	16	22	28	35	41	48	55	61	68	75	82	88	95	102	109	116	123
19	0	4	10	17	23	30	37	44	51	58	65	72	80	87	94	101	109	116	123	130
20	0	4	11	18	25	32	39	47	54	62	69	77	84	92	100	107	115	123	130	138

*Dashes in the body of the table indicate that no decision is possible at the stated level of significance.
For any N_A and N_B the observed value of U is significant at a given level of significance if it is *equal* to or *less* than the critical values shown.

Source: R. Runyon and A. Haber (1976). *Fundamentals of behavioural statistics* (3rd ed.). Reading, MA: McGraw Hill, Inc. With the kind permission of the publisher.

APPENDIX 2: SIGN TEST

	Level of significance for one-tailed test				
	.05	.025	.01	.005	.0005
	Level of significance for two-tailed test				
N	.10	.05	.02	.01	.001
5	0	—	—	—	—
6	0	0	—	—	—
7	0	0	0	—	—
8	1	0	0	0	—
9	1	1	0	0	—
10	1	1	0	0	—
11	2	1	1	0	0
12	2	2	1	1	0
13	3	2	1	1	0
14	3	2	2	1	0
15	3	3	2	2	1
16	4	3	2	2	1
17	4	4	3	2	1
18	5	4	3	3	1
19	5	4	4	3	2
20	5	5	4	3	2
25	7	7	6	5	4
30	10	9	8	7	5
35	12	11	10	9	7

Calculated S must be *equal* to or *less* than the tabled (critical) value for significance at the level shown.

Source: F. Clegg (1983). *Simple statistics*. Cambridge, UK: Cambridge University Press. Reproduced by permission of Cambridge University Press.

APPENDIX 3: WILCOXON SIGNED RANKS TEST

	Levels of significance			
	One-tailed test			
	.05	.025	.01	.001
	Two-tailed test			
Sample size	.1	.05	.02	.002
N = 5	*T* ⩽ 0			
6	2	0		
7	3	2	0	
8	5	3	1	
9	8	5	3	
10	11	8	5	0
11	13	10	7	1
12	17	13	9	2
13	21	17	12	4
14	25	21	15	6
15	30	25	19	8
16	35	29	23	11
17	41	34	27	14
18	47	40	32	18
19	53	46	37	21
20	60	52	43	26
21	67	58	49	30
22	75	65	55	35
23	83	73	62	40
24	91	81	69	45
25	100	89	76	51
26	110	98	84	58
27	119	107	92	64
28	130	116	101	71
29	141	125	111	78
30	151	137	120	86
31	163	147	130	94
32	175	159	140	103
33	187	170	151	112

Calculated T must be *equal* to or *less* than the tabled (critical) value for significance at the level shown.

Source: From R. Meddis (1975). *Statistical handbook for non-statisticians*. London: McGraw-Hill.

APPENDIX 4: SPEARMAN'S RHO TEST

	Level of significance for two-tailed test			
	.10	.05	.02	.01
	Level of significance for one-tailed test			
	.05	.025	.01	.005
$N = 4$	1.000			
5	0.900	1.000	1.000	
6	0.829	0.886	0.943	1.000
7	0.714	0.786	0.893	0.929
8	0.643	0.738	0.833	0.881
9	0.600	0.700	0.783	0.833
10	0.564	0.648	0.745	0.794
11	0.536	0.618	0.709	0.755
12	0.503	0.587	0.671	0.727
13	0.484	0.560	0.648	0.703
14	0.464	0.538	0.566	0.675
15	0.443	0.521	0.604	0.654
16	0.429	0.503	0.582	0.635
17	0.414	0.485	0.566	0.615
18	0.401	0.472	0.550	0.600
19	0.391	0.460	0.535	0.584
20	0.380	0.447	0.520	0.570
21	0.370	0.435	0.508	0.556
22	0.361	0.425	0.496	0.544
23	0.353	0.415	0.486	0.532
24	0.344	0.406	0.476	0.521
25	0.337	0.398	0.466	0.511
26	0.331	0.390	0.457	0.501
27	0.324	0.382	0.448	0.491
28	0.317	0.375	0.440	0.483
29	0.312	0.368	0.433	0.475
30	0.306	0.362	0.425	0.467

For $n > 30$, the significance of r_s can be tested by using the formula:

$$t = r_s\sqrt{\frac{n-2}{1-r_s^2}} \quad \mathrm{df} = n - 2$$

and checking the value of t.

Calculated r_s must *equal* or *exceed* the tabled (critical) value for significance at the level shown.

Source: J.H. Zhar (1972). Significance testing of the Spearman rank correlation coefficient. *Journal of the American Statistical Association*, *67*, 578–80. Reprinted with permission.

APPENDIX 5: CHI-SQUARED TEST

	Level of significance for one-tailed test					
	.10	.05	.025	.01	.005	.0005
	Level of significance for two-tailed test					
df	.20	.10	.05	.02	.01	.001
1	1.64	2.71	3.84	5.41	6.64	10.83
2	3.22	4.60	5.99	7.82	9.21	13.82
3	4.64	6.25	7.82	9.84	11.34	16.27
4	5.99	7.78	9.49	11.67	13.28	18.46
5	7.29	9.24	11.07	13.39	15.09	20.52
6	8.56	10.64	12.59	15.03	16.81	22.46
7	9.80	12.02	14.07	16.62	18.48	24.32
8	11.03	13.36	15.51	18.17	20.09	26.12
9	12.24	14.68	16.92	19.68	21.67	27.88
10	13.44	15.99	18.31	21.16	23.21	29.59
11	14.63	17.28	19.68	22.62	24.72	31.26
12	15.81	18.55	21.03	24.05	26.22	32.91
13	16.98	19.81	22.36	25.47	27.69	34.53
14	18.15	21.06	23.68	26.87	29.14	36.12
15	19.31	22.31	25.00	28.26	30.58	37.70
16	20.46	23.54	26.30	29.63	32.00	39.29
17	21.62	24.77	27.59	31.00	33.41	40.75
18	22.76	25.99	28.87	32.35	34.80	42.31
19	23.90	27.20	30.14	33.69	36.19	43.82
20	25.04	28.41	31.41	35.02	37.57	45.32
21	26.17	29.62	32.67	36.34	38.93	46.80
22	27.30	30.81	33.92	37.66	40.29	48.27
23	28.43	32.01	35.17	38.97	41.64	49.73
24	29.55	33.20	36.42	40.27	42.98	51.18
25	30.68	34.38	37.65	41.57	44.31	52.62
26	31.80	35.56	38.88	42.86	45.64	54.05
27	32.91	36.74	40.11	44.14	46.96	55.48
28	34.03	37.92	41.34	45.42	48.28	56.89
29	35.14	39.09	42.69	46.69	49.59	58.30
30	36.25	40.26	43.77	43.49	50.89	59.70
32	38.47	42.59	46.19	50.49	53.49	62.49
34	40.68	44.90	48.60	53.00	56.06	65.25
36	42.88	47.21	51.00	55.49	58.62	67.99
38	45.08	49.51	53.38	57.97	61.16	70.70
40	47.27	51.81	55.76	60.44	63.69	73.40
44	51.64	56.37	60.48	65.34	68.71	78.75
48	55.99	60.91	65.17	70.20	73.68	84.04
52	60.33	65.42	69.83	75.02	78.62	89.27
56	64.66	69.92	74.47	79.82	83.51	94.46
60	68.97	74.40	79.08	84.58	88.38	99.61

Calculated value of χ^2 must *equal* or *exceed* the tabled (critical) value for significance at the level shown.

Abridged from R.A. Fisher and F. Yates (1974). *Statistical tables for biological, agricultural and medical research* (6th ed.). Harlow, UK: Addison Wesley Longman.

Glossary

accommodation: in Piaget's theory, changes in an individual's cognitive organization to deal with the environment.
adaptive expertise: using acquired knowledge to solve familiar problems efficiently; see **routine expertise**.
adipocytes: body cells that store fat; several overweight individuals often have many more of these cells than those of normal weight.
adipose tissue: tissue consisting of fat cells.
affectionless psychopathy: a disorder found among juvenile delinquents involving a lack of guilt and remorse.
aggression: behavior intended to harm or injure another person.
agoraphobia: a disorder in which there is fear of public places from which it might be difficult to escape in the event of a panic attack.
agrammatism: a condition in brain-damaged patients in which speech lacks grammatical structure and many function words and word endings are omitted.
algorithms: computational procedures providing a specified set of steps to a solution.
alpha bias: the tendency to exaggerate differences between the sexes.
altruism: a form of **prosocial behavior** that is costly to the individual and is motivated by the desire to help the other person.
amblyopia: a condition involving impaired vision as a result of disuse of one eye in the absence of any obvious damage to it.
amnesia: a condition caused by brain damage in which there is substantial impairment of long-term memory; the condition includes both **anterograde amnesia** and **retrograde amnesia**.
anaclitic depression: a condition involving loss of appetite and feelings of helplessness.
androgens: sex hormones found in greater amounts in males than in females.
anterograde amnesia: a reduced ability to remember information acquired *after* the onset of **amnesia**.
antibodies: protein molecules that attach themselves to invaders, marking them out for subsequent destruction.
antigens: foreign bodies such as viruses.
apparent motion: the illusion of movement created by the rapid presentation of still images.
assimilation: in Piaget's theory, dealing with new environmental situations by using existing cognitive organizations.
attachment: strong and long-lasting emotional ties to another person.
attitudes: beliefs about some person, group, or object, with these beliefs having an evaluative component (good vs. bad).
attributions: beliefs about the causes of behavior.
auditory phonological agnosia: a condition in which there is poor auditory perception of unfamiliar words and non-words but not of familiar words.
authoritarian personality: a type of personality characterized by rigid beliefs, hostility towards other groups, and submissive attitudes towards those in authority.
autism: a severe disorder involving very poor communication skills, deficient social and language development, and repetitive behavior.
aversion therapy: a form of treatment in which an aversive stimulus is paired with a positive one (e.g., sight of alcohol) to inhibit the response to the positive stimulus (e.g., drinking).
aversive racism: a combination of beliefs in equality for all and negative emotions towards members of other races.
avoidance learning: a form of **operant conditioning** in which an appropriate avoidance response prevents presentation of an unpleasant or aversive stimulus.
bar chart: a graph showing the frequencies with which the participants in a study fall into different categories.
behaviorism: an American school of psychology with an emphasis on measuring and predicting observable behavior.
beta bias: the tendency to minimize differences between the sexes.
binocular rivalry: this occurs when an observer perceives only one visual stimulus when two are presented, one to each eye.
blindsight: the ability of some brain-damaged patients to respond appropriately to visual stimuli in the absence of conscious visual perception.
blocking: the failure of a conditioned stimulus to produce a conditioned response because another conditioned stimulus already predicts the presentation of the unconditioned stimulus.
body mass index (BMI): an individual's weight in kilos dived by his/her height in meters squared; the normal range is between 20 and 25.
bogus pipeline: a set-up in which participants are attached to a machine they have been told can detect lies.
bounded rationality: the notion that people are as rational as their processing limitations permit.
case study: detailed investigation of a single individual.
category-specific deficits: disorders caused by brain damage in which patients have problems with some semantic categories but not with others.
catharsis: the notion that behaving aggressively can cause a release of negative emotions such as anger and frustration.
centration: attending to only one aspect of a situation.
change blindness: failure to detect changes in the visual environment.
change blindness blindness: people's mistaken belief that they would notice visual changes that are in fact very rarely detected.
chi-squared test: a test of association that is used with nominal data in the form of frequencies.
child-directed speech: the simplified sentences spoken by mothers and other adults when talking to young children.
chunks: stored units formed from integrating smaller pieces of information.
circadian rhythm: any biological rhythm repeating every 24 hours or so.
classical conditioning: a basic form of learning in which simple responses (e.g., salivation) are associated with a new or conditioned stimulus.
clause: part of a sentence that contains a subject and a verb.
clinical method: an informal question-based approach used by Piaget to assess children's understanding of problems.
co-articulation: the finding that the production of a **phoneme** in one speech segment is influenced (and distorted) by the production of the previous sound and preparations for the next sound.
coding units: the categories into which observations are placed prior to analysis.

coercive cycle: a pattern of behavior in which aggression by one family member produces an aggressive response, and so on.

cognitive appraisal: assessment of a situation to decide whether it is stressful and whether the individual has the resources to cope with it.

cognitive dissonance: an unpleasant psychological state occurring when someone has two discrepant cognitions or thoughts.

cognitive neuroscience: an approach within cognitive psychology that involves combining brain-imaging data with behavioral measures to understand human cognition.

cognitive triad: the depressed person's negative views of the self, the world, and the future.

collectivism: characteristic of cultures emphasizing interdependence, sharing of responsibility, and group membership.

common factors: general factors found in most forms of therapy (e.g., therapist's personal qualities) that help the client to recover; see **specific factors**.

comorbidity: presence in the same individual of two or more mental disorders at the same time.

compliance: the influence of a majority on a minority based on the power of the majority; see **conversion**.

concordance rate: as applied to twins, the probability that one twin has a given disorder given that the co-twin has it.

concurrent validity: assessing **validity** by correlating scores on a test with some currently available relevant criterion.

conditioned reflex: the new association between a stimulus and response formed in **classical conditioning**.

conditioned response: a response which is produced by the conditioned stimulus after a learning process in which the conditioned stimulus has been paired several times with the **unconditioned stimulus**.

conditioned stimulus: a stimulus that becomes associated through learning with the **unconditioned stimulus**.

conformity: yielding to group pressures in the absence of a direct request or order.

confounding variables: variables that are mistakenly manipulated or allowed to vary along with the independent variable.

connectionist networks: they consist of elementary units or nodes that are strongly interconnected; each network has various layers.

consensual validity: the extent to which scores on a self-report questionnaire correlate with scores obtained from ratings provided by other people.

conservation: the principle that quantities remain constant under various changes to their appearance.

consolidation: a process mostly completed within several hours, but which can last for years, which fixes information in **long-term memory**.

constant error: any unwanted variable that has a systematically different effect on the dependent variable in different conditions.

content analysis: a method involving the detailed study of, for example, the output of the media, speeches, and literature.

controlled variables: variables, not of interest to the experimenter, that are held constant or controlled.

conventional morality: this is the second level in Kohlberg's theory; at this level, moral reasoning focuses on having others' approval.

conversion: the influence of a minority on a majority based on convincing the majority that its views are correct; see **compliance**.

coping: efforts to deal with demanding situations to master the situation or reduce the demands.

core self-evaluations: a personality dimension including self-esteem, emotional stability (low **neuroticism**), internal locus of control, and generalized self-efficacy.

correlation: an association that is found between two variables.

counterbalancing: this is used with the repeated measures design, and involves ensuring that each condition is equally likely to be used first and second by the participants.

cross-cultural psychology: an approach to psychology focusing on the similarities and differences across cultures.

cross-situational consistency: the extent to which any given individual responds in the same way to different situations.

culture-bound syndromes: patterns of disordered behavior typically found in only certain cultures.

declarative memory: a form of long-term memory concerned with knowing that something is the case; it includes **episodic memory** and **semantic memory**.

deferred imitation: in Piaget's theory, the ability to imitate behavior observed at an earlier time.

deindividuation: the loss of a sense of personal identity that occurs when individuals find themselves in a crowd.

deliberate practice: systematic practice in which the learner is given informative feedback about his/her performance and has the opportunity to correct his/her errors.

demand characteristics: cues used by participants to try to guess the nature of the study or to work out what the experiment is about.

dependent variable: some aspect of the participant's behavior that is measured in a study.

deprivation: the state of a child who has formed a close relationship to someone but is later separated from that person.

derived etic: this involves researchers in various cultures developing techniques that are appropriate within their culture and then comparing the findings; see **imposed etic**.

diathesis–stress model: the notion that mental disorders are caused jointly by a diathesis or vulnerability within the individual *and* a distressing event.

dichotic listening task: a task in which pairs of items are presented one to each ear, followed by recall of all items.

differential parental investment: the notion that females have greater parental investment than males, as a result of which they are more selective in their choice of mates.

diffusion of responsibility: the reduction in a sense of responsibility as the number of observers of an incident increases.

digit span: the number of random digits that can be repeated back correctly in order after hearing them once; it is used as a measure of short-term memory capacity.

discourse analysis: a qualitative form of analysis applied to language productions in spoken or written form.

discrimination: [in intergroup processes] negative actions or behavior directed against the members of some group.

discrimination: [in conditioning and learning] the strength of the **conditioned response** to one **conditioned stimulus** is strengthened at the same time as that to a second conditioned stimulus is weakened.

dispositional attributions: deciding that someone's behavior is caused by their internal dispositions or characteristics.

dizygotic twins: fraternal twins derived from two fertilized ova and sharing 50% of their genes.

double blind: a procedure in which neither the experimenter nor the participants know the precise aims of the study; where possible, they do not know the condition in which each participant has been placed.

double dissociation: the finding that some individuals (often brain-damaged) do well on task A and poorly on task B, whereas others show the opposite pattern.

eclecticism: the use of a range of different forms of treatment by a therapist rather than favoring a single therapeutic approach.

ecological validity: the extent to which the findings of laboratory studies are applicable to everyday settings and generalize to other locations, times, and measures.

effectiveness studies: assessments of therapeutic effectiveness based on typical clinical practice; see **efficacy studies**.

efficacy studies: assessments of therapeutic effectiveness based on well-controlled investigations of well-defined clinical problems.

effort justification: creating a conflict between attitudes and behavior when people make great efforts to achieve a modest goal.

egocentrism: the assumption that one's way of thinking is the only possibility.

elaborative inferences: inferences that add details to a text that is being read but that are not essential to understanding.

emic constructs: these are constructs that are meaningful within any given culture but vary considerably across cultures.

emotional intelligence: the ability to understand one's own emotions as well as those of others.

empathy: the ability to understand another person's point of view and to share their emotions.

encoding specificity principle: the notion that retrieval depends on the overlap between the information available at retrieval and the information within the memory trace.

endogenous mechanisms: mechanisms that are internal and biological and are relatively uninfluenced by external factors.

episodic memory: a form of long-term memory concerned with personal experiences or episodes that happened in a given place at a specific time; see **semantic memory**.

equilibration: using the processes of accommodation and assimilation to produce a state of equilibrium or balance.

equipotentiality: the notion in **operant conditioning** that any response can be conditioned in any stimulus situation.

estrogens: sex hormones found in greater amounts in females than in males.

etic constructs: these are constructs that are meaningful within most or all cultures.

evaluation apprehension: anxiety-toned concern felt by participants in a study to perform well and to be evaluated positively by the experimenter.

evolutionary psychology: an approach based on the notion that much human behavior can be understood on the basis of Darwin's theory of evolution.

expansions: fuller and more detailed versions of what a child has just said provided by an adult or an older child.

experimental hypotheses: the testable predictions generated by a theory; these usually specify independent and dependent variables.

experimental method: an approach to research involving manipulation of some aspect of the environment (independent variable) to observe its effects on the participants' behavior (dependent variable).

experimental realism: the use of an artificial situation in which the participants become fully involved.

experimental validity: the extent to which a finding is genuine, and is a result of the **independent variable** being manipulated.

experimenter effects: the various ways in which the experimenters' expectancies, personal characteristics, misrecordings of data, and so on can influence the findings of a study.

expertise: the specific knowledge an expert has about a given domain (e.g., that an engineer may have about bridges).

explicit learning: learning that involves conscious awareness of what has been learned; see **implicit learning**.

exposure therapy: a form of treatment in which clients are repeatedly exposed to stimuli or situations they greatly fear.

extended contact effect: knowledge that a member of your ingroup has formed a close relationship with a member of another group can reduce prejudice against that other group.

external validity: the validity of an experiment outside the research situation itself; the extent to which its findings are applicable to everyday life and generalize across populations, locations, measures, and times, see **internal validity**.

extinction: [in conditioning and learning] the elimination of a response when it is not followed by reward (**operant conditioning**) or by the unconditioned stimulus (**classical conditioning**).

extinction: [in visual perception and attention] a disorder of visual attention in which a stimulus presented to the side opposite the brain damage is not detected when another stimulus is presented at the same time.

extraversion: a personality factor based on sociability and impulsiveness.

factor analysis: a statistical technique applied to intelligence tests to find out the number and nature of the aspects of intelligence they are measuring.

false uniqueness bias: the mistaken tendency to think of oneself as being better than most other people.

falsifiability: the notion that all scientific theories can in principle be disproved by certain findings.

fatal familial insomnia: an inherited disorder in which the ability to sleep disappears in middle age and is followed by death several months later.

field experiment: a study in which the experimental method is used in a naturalistic situation.

figure–ground segregation: the perceptual organization of the visual field into a figure (object of central interest) and a ground (less important background).

fixation: in Freudian theory, spending a long time at a given stage of psychosexual development.

fixed interval schedule: a situation in which every the first response produced after a given interval of time is rewarded or reinforced.

fixed ratio schedule: a situation in which every *n*th response is rewarded.

flashbulb memories: vivid and detailed memories of dramatic events (e.g., September 11).

Flynn effect: the rapid rise in average IQ in several Western countries in recent decades.

framing effect: the influence of irrelevant aspects of a situation (e.g., wording of the problem) on decision making.

free association: a technique used in psychoanalysis in which the client says whatever comes immediately to mind.

frequency polygon: a graph showing the frequencies with which different scores are obtained by the participants in a study.

Freudian slip: an error in speech or action that is motivated by unconscious desires.

functional fixedness: the inflexible use of the usual function(s) of an object in problem solving.

functional magnetic resonance imaging (fMRI): a technique providing information about brain activity based on the detection of magnetic changes; it has reasonable temporal and spatial resolution.

fundamental attribution error: exaggerating the importance of personality and minimizing the role of the situation in determining another person's behavior.

fundamental lexical hypothesis: the assumption that dictionaries contain words describing all of the main personality traits.

gametes: sexual reproductive cells consisting of sperm in males and of eggs in females.

gender identity: a boy's or a girl's awareness of being male or female, respectively.

gender schemas: organized beliefs about suitable activities and behavior for each gender.

generalizability: the extent to which the findings of a study apply to other settings, populations, times, and measures.

generalization: the tendency of a **conditioned response** to occur (but in a weaker form) to stimuli similar to the **conditioned stimulus**.

genotype: an individual's potential in the form of genes.

glycogen: a carbohydrate produced by combining glucose molecules to create an energy store.

grammatical morphemes: modifiers (e.g., prefixes; suffixes) that alter the meaning of words and phrases.

group cohesiveness: the extent to which group members are attracted to the idea of the group.

group norms: rules and standards generally accepted by group members.

group polarization: the tendency for groups to produce fairly extreme decisions.

group socialization: dynamic processes in which group members and groups influence each other.

grouping: in Piaget's theory, a set of logically related operations.

groupthink: an excess focus on consensus that typically produces poor group decisions.

hard determinism: the notion that all of our actions are totally determined by a combination of causes; see **soft determinism**.

hassles: the irritating challenges of everyday life that can increase stress levels.

health literacy: the ability to understand health-related issues (e.g., taking medications appropriately).

heritability: the ratio of genetically caused variation to total variation (a combination of genetic and environmental variation) within a given population.

heuristics: rules of thumb that often (but not invariably) solve any given problem.

hill climbing: a **heuristic** that involves changing the present state of a problem into one apparently closer to the goal.

histogram: a graph in which the frequencies with which different scores are obtained by the participants in a study are shown by rectangles of different heights.

idiot savants: individuals who have limited outstanding expertise in spite of being mentally retarded.

ill-defined problems: problems in which the definition of the problem statement is imprecisely specified; the initial state, goal state, and methods to be used to solve the problem may be unclear; see **well-defined problems**.

immune system: a system of cells in the body involved in fighting disease.

implacable experimenter: the typical laboratory situation in which the experimenter's behavior is uninfluenced by the participant's behavior.

implementation intentions: intentions specifying in detail how an individual is going to achieve some goal.

implicit attitudes: attitudes that are outside conscious awareness and control.

implicit learning: learning information without conscious awareness of having learned; see **explicit learning**.

imposed etic: this involves applying techniques and/or theories based on one culture to other cultures without considering differences among cultures; see **derived etic**.

inattentional blindness: failure to detect an unexpected object appearing in a visual display; see **change blindness**.

inclusive fitness: the notion that natural selection favors individuals who maximize replication of their genes either directly via reproduction or indirectly by helping others who are genetically related to them.

incubation: the finding that a problem is solved more easily when it is put aside for some time; sometimes claimed to depend on unconscious processes.

independent variable: some aspect of the experimental situation that is manipulated by the experimenter.

individualism: characteristic of cultures emphasizing independence, personal responsibility, and personal uniqueness.

induced compliance: creating **cognitive dissonance** by persuading people to behave in ways opposed to their attitudes.

infantile amnesia: the inability of adults to recall autobiographical memories from early childhood.

informational influence: this occurs when an individual conforms because others in the group are believed to possess more knowledge.

ingroup bias: the tendency to favor one's ingroup over one or more outgroups.

insight: the experience of suddenly realizing how to solve a problem.

insight: a Freudian term meaning conscious understanding of traumatic thoughts and feelings that have been subject to **repression**.

integrative agnosia: a condition in which the patient experiences great difficulty in integrating features of an object when engaged in object recognition.

intelligence quotient: a measure of general intellectual ability; the mean IQ is 100.

internal validity: the validity of an experiment in terms of the context in which it is carried out, including the extent to which its findings can be replicated; also the extent to which research findings are genuine and can be regarded as being caused by the **independent variable**; see **external validity**.

interquartile range: the spread of the middle 50% of an ordered or ranked set of scores.

interval data: data in which the units of measurement have an invariant or unchanging value.

jargon aphasia: a brain-damaged condition in which speech is reasonably correct grammatically, but there are great problems in finding the right words.

jigsaw classroom: an approach to teaching designed to reduce prejudice in which the teacher ensures that all children in the class contribute to the achievement.

kin selection: the notion that natural selection favors individuals assisting those genetically related to them.

knowledge bias: the tendency to disregard a message if the source seems to lack accurate knowledge.

language acquisition device: an innate knowledge of the grammatical structure of language.

latent content: in Freud's theory, the underlying meaning of a dream that is difficult to recollect consciously; see **manifest content**.

law of effect: the probability of a response being produced is increased if it is followed by reward but is decreased if it is followed by punishment.

leptin: a protein secreted by fat cells that decreases feeding behavior.

life events: predominantly negative occurrences (and often of major consequence) that typically produce increased stress levels.

Likert scale: an approach to attitude measurement in which respondents indicate the strength of their agreement or disagreement with various statements.

linguistic universals: features that are found in all (or virtually all) languages.

long-term working memory: this is used by experts to store relevant information in long-term memory and to access it through retrieval cues in **working memory**.

loss aversion: the notion that individuals are more sensitive to potential losses than they are to potential gains.

major depressive disorder: a disorder characterized by symptoms such as sad, depressed mood, tiredness, and loss of interest in various activities.

manifest content: in Freud's theory, the remembered, "cleaned up" meaning of a dream; see **latent content**.

McGurk effect: the **phoneme** perceived in speech is influenced by visual and acoustic information when the two are in conflict.

mean: an average worked out by dividing the total of all participants' scores by the number of participants.

means–end relationship: the knowledge that responding in a particular way in a given situation will produce a certain outcome.

means–ends analysis: a **heuristic** for solving problems based on noting the difference between a current and a goal state, and creating a sub-goal to overcome this difference.

median: the middle score out of all participants' scores in a given condition.

melatonin: a hormone playing a key role in the onset of sleep.

meta-analysis: an analysis in which all of the findings from many studies relating to a given hypothesis are combined for statistical testing to obtain an overall picture.

metacognition: an individual's beliefs and knowledge about his/her own cognitive processes and strategies.

metamemory: knowledge about one's memory and about how it works.

microgenetic method: an approach to studying children's changes in cognitive strategies by means of short-term longitudinal studies.

misdirection: the various techniques used by magicians to make spectators focus on some irrelevant aspect of the situation while they perform the crucial part of a trick.

mixed error effect: speech errors that are semantically and phonologically related to the intended word.

mode: the most frequently occurring score among the participants in a given condition.

monotropy: the notion that infants have an innate tendency to form strong bonds with one particular individual (typically the mother).

monozygotic twins: identical twins derived from a single fertilized ovum and sharing 100% of their genes.

mood-state-dependent memory: the finding that memory is better when the mood state at retrieval is the same as that at learning than it is when the two mood states differ.

morphemes: the smallest units of meaning within words.

multitasking: performing two or more tasks at the same time by switching rapidly between them.

mundane realism: the use of an artificial situation that closely resembles a natural situation.

natural experiment: a type of **quasi-experiment** in which use is made of some naturally occurring event.

negative affectivity: a personality dimension involving a tendency to experience negative emotional states such as anxiety and depression.

negative contrast effect: a marked reduction in response rate in **operant conditioning** when there is a decrease in the size of the reinforcer.

negative punishment: a form of operant conditioning in which the probability of a response being produced is reduced by following it with the removal of a positive reinforcer or reward.

negative transfer: past experience in solving problems disrupts the ability to solve a current problem.

neglect: a disorder of visual attention in which stimuli (or parts of stimuli) presented to the side opposite the brain damage are not detected; the condition resembles **extinction** but is more severe.

neologisms: made-up words that are often found in the speech of patients with **jargon aphasia**.

neoteny: an extended period or duration of childhood resulting from evolution.

neuropeptide Y: a neurotransmitter that increases feeding behavior.

neuroticism: a personality factor based on negative emotional experiences (e.g., anxiety and depression).

nominal data: data consisting of the numbers of participants falling into qualitatively different categories.

nonparametric tests: statistical tests that do not involve the requirements of parametric tests.

nonshared environment: environmental influences that are unique to a given individual.

normal distribution: a bell-shaped distribution in which most scores cluster fairly close to the mean.

normative influence: this occurs when an individual conforms so that others in the group will like or respect him/her.

normative theories: as applied to decision making, theories focusing on how people should make decisions.

null hypothesis: prediction that the **independent variable** will have no effect on the **dependent variable**.

obesity: the condition of being substantially overweight, defined as having a **body mass index** exceeding 30.

object permanence: an awareness that objects continue to exist when they can no longer be seen.

objective tests: a method of assessing personality under laboratory conditions in an unobtrusive way.

observational learning: learning occurring as a consequence of watching the behavior of another person (often called a model).

Oedipus complex: the Freudian notion that boys at the age of 5 desire their mother and so become frightened of their father.

operant conditioning: a form of learning in which behavior is controlled by its consequences (i.e., rewards or positive reinforcers and unpleasant or aversive stimuli).

operationalization: a procedure in which variables of interest are defined by the operations taken to measure them.

opportunity sampling: selecting participants only on the basis of their availability.

optic ataxia: a condition involving brain damage in which the patient has difficulty in making visually guided movements in spite of having reasonably intact visual perception.

ordinal data: data that can be ordered from smallest to largest.

over-regularization: extending a grammatical rule to situations in which it does not apply.

oxytocin: a hormone produced in response to stress that reduces anxiety and increases sociability.

panic disorder: a disorder in which an individual suffers from panic attacks and is very concerned about having further attacks.

paradigm: according to Popper, a general theoretical orientation commanding wide support.

parametric tests: statistical tests that require interval or ratio data, normally distributed data, and similar variances in both conditions.

parsing: an analysis of the syntactical or grammatical structure of sentences.

partial penetrance: a characteristic of certain genes, in which they influence behavior only under certain conditions.

participant reactivity: the situation in which an independent variable has an effect on behavior merely because the participants are aware they are being observed.

peak experiences: heightened experiences associated with feelings of joy and wonder.

peer tutoring: teaching of one child by another, with the child doing the teaching generally being slightly older than the one being taught.

perseverative search: mistakenly searching for an object in the place in which it was previously found rather than the place in which it is currently hidden.

personal identity: those aspects of the **self-concept** that depend on our personal relationships and characteristics.

phenomenology: an approach in which the focus is on the individual's direct reports of experience.

phenotype: an individual's observable characteristics based on his/her genotype plus life experiences.

phonemes: basic speech sounds that distinguish one word from another and so convey meaning.

phonemic restoration effect: the finding that listeners are unaware that a phoneme has been deleted from an auditorily presented sentence.

phonological dyslexia: a condition in which familiar words can be read but there is impaired ability to read unfamiliar words and non-words.

phonological similarity effect: the finding that immediate recall of word lists in the correct order is impaired when the words sound similar to each other.

phonology: information about the sounds of words and parts of words.

phrase: a group of words expressing a single idea; it is shorter than a **clause**.

positive punishment: a form of operant conditioning in which the probability of a response is reduced by following it with an unpleasant or aversive stimulus; sometimes known simply as punishment.

positive transfer: past experiencing of solving problems makes it easier to solve a current problem.

post-conventional morality: the third level in Kohlberg's theory; at this level, moral reasoning focuses on justice and the need to respect others.

posttraumatic stress disorder: a disorder triggered by a very distressing event and involving re-experiencing of the event, avoidance of stimuli associated with the event, and increased arousal.

pre-conventional morality: the first level in Kohlberg's theory; at this level, moral reasoning focuses on rewards for good actions and punishments for bad actions.

predictive validity: assessing **validity** by correlating scores on a test with some future criterion.

preformulation: this is used in speech production to reduce processing costs by using phrases often used previously.

prejudice: an attitude or belief (usually negative) towards the members of some group on the basis of their membership of that group.

preparedness: the notion that each species finds some forms of learning more "natural" and easier than others.

primacy effect: in social psychology, the notion that our impressions of other people are heavily influenced by the first information about them we encounter.

primary reinforcers: rewarding stimuli that are needed to live (e.g., food; water).

privation: the state of a child who has never formed a close attachment with anyone.

proactive interference: disruption of memory by previous learning, often of similar material; see **retroactive interference**.

problem representation: the way in which the problem solver represents a problem based on what seem to be its crucial features.

problem space: an abstract description of all the possible states of affairs that can occur in a problem situation.

progress monitoring: this is a **heuristic** used in problem solving in which insufficiently rapid progress towards solution produces criterion failure and the adoption of a different strategy.

projective tests: a method of assessing personality in which people are given an unstructured test to perform (e.g., describing inkblots).

proposition: a statement that makes an assertion or denial and which can be true or false.

prosocial behavior: cooperative, affectionate, or helpful behavior designed to benefit another person.

psychobiography: the study of individual personality by applying psychological theory to the key events in a person's life.

psychological refractory period (PRP) effect: the slowing of response to the second of two stimuli when presented close together in time.

psychopathology: the study of the nature and development of mental disorders; an abnormal pattern of functioning.

psychoticism: a personality factor based on aggression, hostility, and a lack of caring.

quasi-experiment: a type of experiment resembling a "true" experiment, but with some aspects of the experimental method omitted.

quota sampling: selecting participants at random from a population so that they are similar to it in certain respects (e.g., proportion of females; proportion of teenagers).

racism: prejudice and/or discrimination against another group because of their race or ethnicity.

random error: unsystematic and unwanted "nuisance variables" that influence the **dependent variable**.

random sampling: selecting participants on some random basis (e.g., coin tossing).

randomization: the allocation of participants to conditions on a random basis.

range: the difference between the highest and lowest score in any condition.

ratio data: as **interval data**, but with a meaningful zero point.

rationalization: in Bartlett's theory, the tendency to recall stories in distorted ways influenced by the reader's cultural expectations and **schemas**.

recategorization: the process of producing a new categorization in which the ingroup and the outgroup are combined into a single ingroup.

reciprocal altruism: the notion that individuals will behave altruistically towards someone else if they anticipate that person will respond altruistically.

reductionism: the notion that psychology can ultimately be reduced to more basic sciences such as physiology or biochemistry.

regression: in Freudian theory, returning to an earlier stage of psychosexual development when someone is highly stressed.

reliability: the extent to which a test gives consistent findings on separate occasions.

REM sleep: a stage of sleep involving rapid eye movements and associated with dreaming.

reminiscence bump: the tendency of older people to recall a disproportionate number of autobiographical memories from the years of adolescence and early adulthood.

replicability: the ability to repeat or replicate findings obtained from an experiment.

replication: the ability to repeat the findings obtained from an experiment.

reporting bias: the tendency to disregard a message if the source seems untrustworthy.

repression: motivated forgetting of traumatic or other very threatening events.

retroactive interference: disruption of memory by learning of other material during the retention interval; see **proactive interference**.

retrograde amnesia: impaired memory for events occurring before the onset of **amnesia**.

reversibility: the ability to undo, or reverse mentally, an action or operation.

routine expertise: using acquired knowledge to develop strategies for dealing with novel problems; see **adaptive expertise**.

saccades: fast eye movements or jumps that cannot be altered after being initiated.

safety-seeking behaviors: actions taken by anxious patients to prevent feared consequences and to reduce their anxiety level.

satisficing: selection of the first choice that meets certain minimum requirements; the word is formed from the two words satisfactory and sufficing.

scaffolding: the context provided by an adult or other knowledgeable person helping children to develop their cognitive skills.

scattergraph: a two-dimensional representation of all the participants' scores in a correlational study; also known as a scattergram.

schema: in Piaget's theory, organized knowledge used to guide action.

schemas: in Bartlett's theory, organized information about the world, events, or people stored in long-term memory.

scripts: organized information or schemas representing typical events.

secondary reinforcers: stimuli that are rewarding because they have been associated with **primary reinforcers**; money and praise are examples.

segmentation problem: the listener's problem of dividing the almost continuous sounds of speech into separate **phonemes** and words.

selective placement: placing adopted children in homes with similar educational and social backgrounds to those of their biological parents.

self-actualization: the need to discover and fulfill one's own potential.

self-concept: the organized body of information an individual possesses about himself/herself.

self-disclosure: revealing personal or intimate information about oneself to someone else.

self-discovery: an active approach to learning in which the child is encouraged to use his/her initiative.

self-efficacy: an individual's beliefs concerning his or her ability to cope successfully with a particular task or situation.

self-esteem: the evaluative part of the **self-concept** concerned with feelings of confidence and being worthwhile.

self-fulfilling prophecy: the tendency for someone's expectations about another person to lead to the fulfillment of those expectations.

self-regulation: using one's own cognitive processes to control and regulate one's own behavior and goals.

self-serving bias: the tendency to take credit for success but to refuse to accept blame for failure.

semantic memory: a form of long-term memory consisting of general knowledge about the world, language, and so on; see **episodic memory**.

sensory buffer: a mechanism that maintains information for a short period of time before it is processed.

sensory-specific satiety: reduced pleasantness of any taste (or food smell) to which an individual has been repeatedly exposed.

sex-role stereotypes: culturally determined beliefs about appropriate male and female behavior.

sex-typed behavior: behavior consistent with **sex-role stereotypes**.

shadowing task: a task in which there are two auditory messages, one of which has to be repeated back aloud or shadowed.

shaping: a form of operant conditioning in which behavior is changed slowly in the desired direction by requiring responses to become more and more like the wanted response for reward to be given.
shared environment: environmental influences common to the children within a given family.
single blind: a procedure in which the participants are not informed of the condition in which they have been placed.
situational attributions: deciding that someone's behavior is caused by the situation in which they find themselves.
size constancy: objects are perceived to have a given size regardless of the size of the retinal image.
social cognition: the cognitive processes involved in making sense of social situations and behavior.
social desirability bias: the tendency to provide socially desirable rather than honest answers on questionnaires and in interviews.
social identity: the part of the **self-concept** depending on the various groups to which we belong.
social influence: a process in which an individual's attitudes and/or behavior are influenced by another person or by a group.
social norms: agreed standards of behavior within a group (e.g., family; organization).
social phobia: a disorder in which the individual has excessive fear of many social situations and will often avoid them.
soft determinism: the notion that all behavior has a cause, but some forms of behavior are more constrained by the current situation than are others.
source traits: personality traits underlying the more superficial surface traits.
specific factors: features unique to a given form of therapy that help the patient to recover; see **common factors**.
specific phobia: a strong and irrational fear of a given object (e.g., spider; snake) or situation (e.g., enclosed space).
spillover effect: any given word is fixated longer during reading when it is preceded by a rare or unpredictable word rather than a common or predictable word.
split attention: allocation of attention to two nonadjacent regions of visual space.
split-brain patients: individuals in whom the corpus callosum connecting the two halves of the brain has been severed.
spontaneous recovery: the re-emergence of responses over time in **classical conditioning** following experimental extinction.
spreading activation: the notion that activation or energy spreads from an activated node (e.g., word) to other related nodes.
standard deviation: a measure of the spread of scores in a bell-shaped or normal distribution. It is the square root of the variance, takes account of every score, and is a sensitive measure of dispersion or variation.
standardized test: a test given to large representative samples so that an individual's scores can be compared to those of the population.
statistical significance: the level at which the decision is made to reject the **null hypothesis** in favor of the **experimental hypothesis**.
stereotype: a simplified cognitive generalization or categorization (typically negative) about a group. It is often based on easily identifiable characteristics (e.g., sex; ethnicity).
stratified sampling: a modified version of **quota sampling**, in which the selection of participants according to certain characteristics is decided by the researcher, rather than in a random way.
subliminal stimuli: these are stimuli presented below the level of conscious awareness.
sunk-cost effect: expending additional resources to justify some previous commitment (i.e., throwing good money after bad).
surface dyslexia: a condition in which brain-damaged patients cannot read irregular words but can read regular ones.
surface traits: personality traits that are readily observable and are related to underlying source traits.
syllable: a rhythmic unit of speech; words consist of one or more syllables.
systematic sampling: a modified version of **random sampling** in which the participants are selected in a quasi-random way (e.g., every hundredth name from a population list).
telegraphic period: a stage of language development in which children use short but informative utterances, as in a telegram.
template: as applied to chess, an abstract, schematic structure consisting of a mixture of fixed and variable information about chess pieces.
theory: a general explanation of a set of findings; it is used to produce experimental hypotheses.
theory of mind: the understanding that other people may have different beliefs, emotions, and intentions than one's own.
third-person effect: the belief that one is personally less influenced by persuasive messages than most other people.
tip-of-the-tongue phenomenon: the experience of having a specific concept in mind but being unable to access the correct word to describe it.
token economy: use of **operant conditioning** to change the behavior of mental patients by selective positive reinforcement or reward.
traits: stable aspects of a person that influence his/her personality.
transactional leadership: a form of leadership involving exchanges or bargains between the leader and his/her followers.
transference: in Freudian theory, the transfer of the patient's strong feelings for one person (e.g., a parent) onto the therapist.
transformational leadership: a form of leadership based on inspiration or charisma.
transitivity: this involves the ability to place at least three entities in the correct order.
triadic reciprocal model: Bandura's view that an individual's personality, the environment, and his/her own behavior all influence each other.
tutorial training: a traditional approach in which the teacher imparts knowledge to fairly passive students.
Type A personality: a personality type characterized by impatience, competitiveness, time pressure, and hostility.
Type D personality: a personality type characterized by high **negative affectivity** and social inhibition.
Type I error: mistakenly rejecting the null hypothesis in favor of the experimental hypothesis when the results are actually a result of chance.
Type II error: mistakenly retaining the null hypothesis when the experimental hypothesis is actually correct.
unconditioned reflex: the new association between a stimulus and response formed in classical conditioning.
unconditioned response: an unlearned response to an unconditioned stimulus.
unconditioned stimulus: a stimulus that produces an unconditioned response in the absence of learning.
unconscious perception: perception occurring below the level of conscious awareness.
underspecification: a strategy used to reduce processing costs in speech production by producing simplified expressions.
utility: the subjective desirability of a given outcome in decision making.
validity: the extent to which a test measures what it claims to be measuring.
variable interval schedule: a situation in which the first response produced after a given interval of time is rewarded but with some variation around that time interval.
variable ratio schedule: on average every *n*th response is rewarded, but there is some variation around that figure.
variance: a measure of dispersion that is the square of the standard deviation.
viewpoint-dependent theories: theories of object recognition based on the assumption that objects can be

recognized more easily from some angles than from others; see **viewpoint-invariant theories**.

viewpoint-invariant theories: theories of object recognition based on the assumption that objects can be recognized equally easily from all angles; see **viewpoint-dependent theories**.

visceral brain: a brain system including the hippocampus, septum, and hypothalamus claimed by H.J. Eysenck to be most responsive in individuals high in neuroticism.

visual agnosia: a condition in which there are great problems in recognizing objects presented visually even though visual information reaches the visual cortex.

weapon focus: the finding that eyewitnesses pay so much attention to a weapon that they tend to ignore other details.

weapons effect: an increase in aggression produced by the sight of a weapon.

well-defined problems: problems in which the initial state, goal, and methods available for solving them are clearly laid out; see **ill-defined problems**.

Williams syndrome: a genetic disorder involving low IQ but reasonable language development.

word meaning deafness: a condition in which there is selective impairment of the ability to understand spoken (but not written) words.

working memory: a system having the functions of cognitive processing and the temporary storage of information.

zeitgeber: external events (e.g., light) that partially determine biological rhythms.

zone of proximal development: in Vygotsky's theory, the gap between the child's current problem-solving ability and his/her potential ability.

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