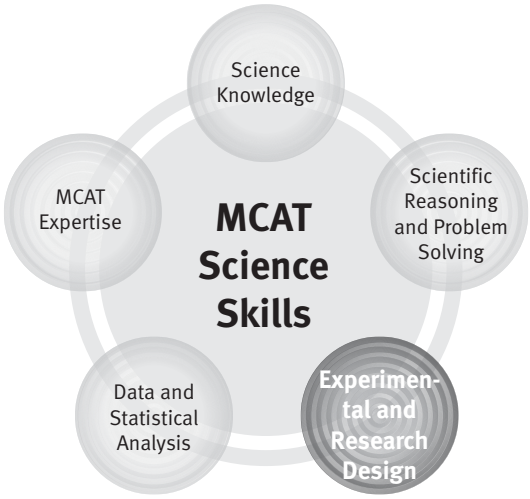
Skill 3 (Research Design) Basics

In this lesson, you'll learn to:

- Recognize the application of the scientific method
- Distinguish between testable and untestable hypotheses
- Identify the independent and dependent variables in an experiment

Science Topics:

- Biological Bases of Behavior
- Sensory Processing



LESSON 3.1, LEARNING GOAL 1:

- Recognize the application of the scientific method

The Scientific Method—An Archetypal Experiment

Dave is **fascinated** by how his friend Rose, who works at a restaurant, is able to hold and carry hot plates that he can't stand to touch. He **does some research** on the subject, learns about sensory thresholds and adaptation, and receives permission from his lab to run a small experiment. **His hypothesis is** that laboratory mice exposed to uncomfortably hot surfaces over a period of time will eventually react less adversely to those hot surfaces.

What question is Dave trying to answer with his experiment?

Data is gathered over the next few weeks. He splits the mice into two groups: one—the experimental group—whose cage floor is made hot for one minute every hour, and the other—the control group—whose cage is left alone and who otherwise live identically to the experimental group. At the end of one week, Dave exposes all mice (in both groups) to a hot surface and monitors their reactions. Upon **analysis of the data**, he immediately sees that mice in the experimental group react less visibly to the hot surface, and some seem to not be affected at all. He therefore **concludes** that his hypothesis was correct, and that his friend Rose is in some ways like the mice in the experimental group: acclimated to hot surfaces.

Why is the second group of mice (the control group) included in the study?

Finally, Dave attempts to **publish** his findings so that others can see his procedure, duplicate the experiment, and see if they yield the same results. If this process also confirms the hypothesis a sufficient number of times, the results are considered **verified**.

Why are these last two steps important to the scientific method?

KAPLAN TIP

The scientific method here, which includes publishing and verification as explicit steps, is a more "institutionalized" version of the method. In a formal sense, studies that are not published can still be called "scientific."

LESSON 3.1, LEARNING GOAL 2:

- Distinguish between testable and untestable hypotheses

Sample Hypotheses

		(Circle one)
"If someone experiences an increase in inter-neuron dopamine levels, he or she reports an increase in positive affect."	**Testable**	**Untestable**
"More brain activity occurs in Broca's area during speech than at other times."	**Testable**	**Untestable**
"The brain processes visual images by using a spatial map on the occipital lobe."	**Testable**	**Untestable**
"People with nasal congestion who take this medicine will normally feel better the next day."	**Testable**	**Untestable**
"If I take this medicine now, I will feel better in the morning."	**Testable**	**Untestable**

The FINER Method

Proposed Study Hypothesis	What's Wrong with It?
Individuals born before 1800, because of pre-industrial air quality, will score higher than today's adults on a modern intelligence test.	
Neurons placed in one brand of carbonated soft drink will have higher conductance than those placed in other brands of soft drink.	
Rhythmic vibrations at higher frequencies are perceived by humans as higher-pitched sounds.	
When ordered to do so by an authority, test subjects will willingly harm another human being.	
Pure gold, when aggregated in weights of more than one metric ton, can act as a moderately effective magnet.	

KAPLAN TIP
Remember that most testable hypotheses either are, or can be rephrased as, "if-then" statements.

LESSON 3.1, LEARNING GOAL 3:

- Identify the independent and dependent variables in an experiment

Experiment 1

… Data is gathered over the next few weeks. He splits the mice into two groups: one—the experimental group—whose cage floor is made hot for one minute every hour, and the other—the control group—whose cage is left alone and who otherwise live identically to the experimental group. At the end of one week, Dave exposes all mice (in both groups) to a hot surface and monitors their reactions …

What is the independent variable in this study?

What is the dependent variable in this study?

Experiment 2

… Running the rat through the same maze multiple times gives a learning curve. The experience variable is the number of times the rat has gone through the maze and the learning variable is the number of mistakes that it has made …

What is the independent variable in this study?

What is the dependent variable in this study?

Experiment 3

… The experimenters compared the relative athletic skill (as measured by sprinting speed, strength, and agility) of identical twins raised together, identical twins raised apart, and fraternal twins raised together. They then set their data next to the variability in athletic skill present in the general population …

What are the independent variables in this study?

What is the dependent variable in this study?

KAPLAN TIP

Certain types of studies are more commonly used in certain experimental fields. For instance, twin studies are used often in behavioral genetics and Stroop tests are often used in studies of working memory and cognitive load. Being familiar with these common types of studies is advantageous on Test Day, but the MCAT won't expect you to know all the details at a single mention of the class of study.

LESSON 3.1 REVIEW

The Scientific Method

1. Generate a testable question
2. Gather data and resources
3. Form a hypothesis
4. Collect new data
5. Analyze the data
6. Interpret the data and existing hypothesis
7. Publish
8. Verify results

The FINER Method for Testable Hypotheses

Is the study you'd like to conduct . . .

- **F**easible?
- **I**nteresting?
- **N**ovel?
- **E**thical?
- **R**elevant?

Independent and Dependent Variables

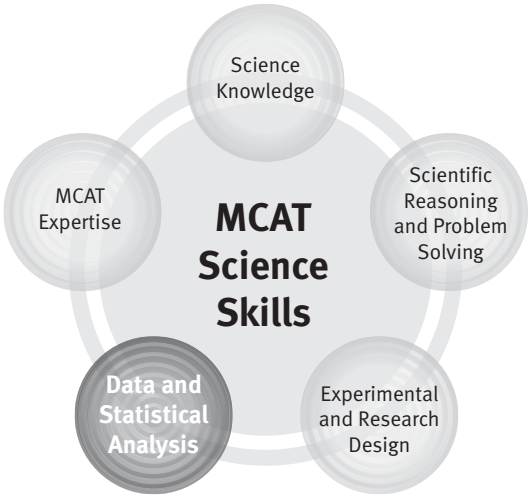
- **Independent variables** are manipulated by the experimenter in a controlled setting
  - In graphical representations, independent variables are generally placed on the *x-axis*
  - When a hypothesis is stated as an "if-then" statement, the independent variable is generally the "*if*" part of the statement

- **Dependent variables** are monitored for change by the experimenter
  - In graphical representations, dependent variables are generally placed on the *y-axis*
  - When a hypothesis is stated as an "if-then" statement, the dependent variable is generally the "*then*" part of the statement
- The *purpose of an experiment* is generally to see if, and by how much, the independent variable has an effect on the dependent variable

Skill 4 (Data Analysis) Basics

In this lesson, you'll learn to:

- Analyze and interpret visual representations of data
- Choose the appropriate representation for a given data set
- Use data to identify and explain relationships between variables
- Use data to determine a study's conclusions and make predictions about the likelihood of future events



Science Topics:

- Sensory Processing
- Biological Bases of Behavior

LESSON 4.1, LEARNING GOAL 1:

- Analyze and interpret visual representations of data

Data Interpretation

Experiment 1
A neuropsychologist is interested in finding out how a specific type of lesion in the reticular formation of the brain stem would affect how long a patient remains in a specific sleep stage. In order to test this, he invited six people with this type of lesion to participate in a simple sleep study.

The results of the study for all six participants are shown in Table 1.

	Hours spent in:	Hours spent in:	Hours spent in:	Hours spent in:	Hours spent in:	Hours spent in:
Person	NREM-1	NREM-2	NREM-3	NREM-4	REM	Total
1	1.0	1.4	1.4	2.0	4.4	10.1
2	1.3	1.1	2.0	1.5	4.0	9.5
3	2.0	1.0	2.1	1.0	3.4	9.5
4	1.2	2.0	1.1	1.5	3.6	9.4
5	2.1	1.0	1.1	3.1	3.5	10.7
6	1.4	1.3	1.2	2.0	3.4	9.3

Table 1. Hours spent in sleep stages in patients with a lesion in the reticular formation.

1. Looking at the results, in which stage of sleep did participants spend the most time?

A. NREM-1
B. NREM-3
C. NREM-4
D. REM

The researcher then compared the time that each participant spent in REM sleep with that of their control counterparts (participants with no lesion in the reticular formation of the brain stem). The results are shown in Figure 1.

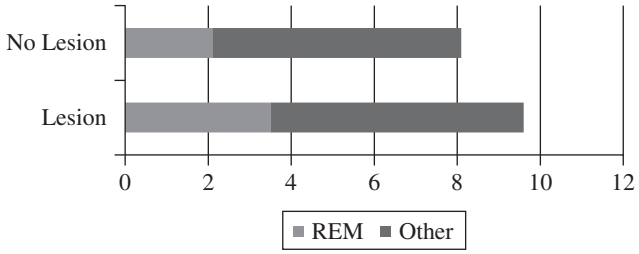


Figure 1. Comparison of REM and NREM sleep times.

2. On average, how do the patients with the lesion compare with their unaffected counterparts?

A. The unaffected control participants slept more and spent more time in REM sleep than the affected counterparts.
B. The unaffected control participants slept less and spent more time in REM sleep than the affected counterparts.
C. The affected participants slept more and spent more time in REM sleep than their unaffected counterparts.
D. The affected participants slept less and spent more time in REM sleep than their unaffected counterparts.

The neuropsychologist partnered with a neurobiologist during the study in order to study the levels of specific neurotransmitters present throughout the different stages of sleep. The results for two of the neurotransmitters are shown in Figure 2.

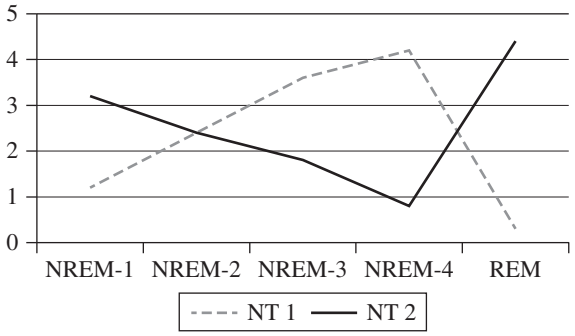


Figure 2. Levels of NT 1 and NT 2 in each sleep stage.

3. Given the information in the graph, during which stage of sleep is the difference between the two neurotransmitter levels the greatest?

A. NREM-1
B. NREM-3
C. NREM-4
D. REM

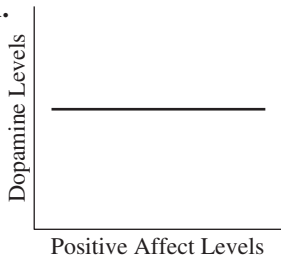
LESSON 4.1, LEARNING GOALS 2 AND 3:

- Choose the appropriate representation for a given data set
- Use data to identify and explain relationships between variables

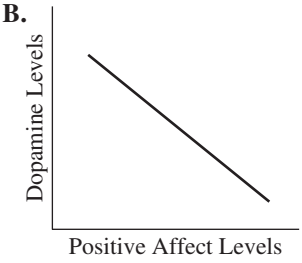
Study 1
A scientist conducts a study to test how levels of interneuron dopamine levels change with an individual's mood. He finds that an improved mood state corresponds with increasing levels of interneuron dopamine over time.

4. Which of the following is the most appropriate representation of the scientist's findings?

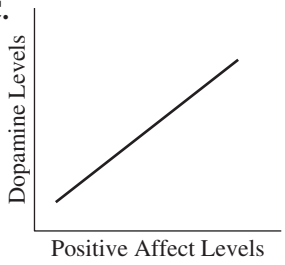
A.



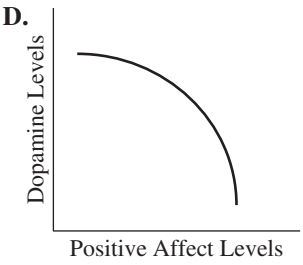
B.



C.



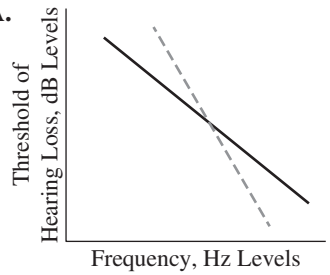
D.



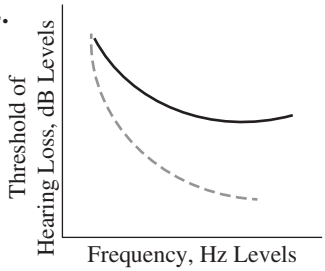
Study 2
In order to study the severity of unilateral sensorineural hearing loss in her patients, a researcher performs audiograms to document their deficits. She finds that patients with this type of hearing loss have a higher frequency threshold than patients without it.

5. Which of the following is the appropriate representation for the scientist's findings if the darker line represents patients with hearing loss and the lighter line represents patients without it?

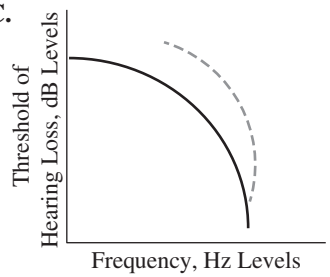
A.



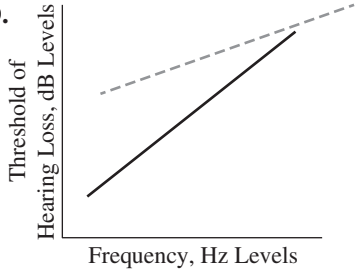
B.



C.



D.



KAPLAN TIP
Determining which visual representation is best for your data set requires an understanding of the goal of the study in the first place.

Study 3
In order to replicate Weber's law for contrast perception, a researcher plots contrast units *vs.* intensity. Results are shown in Figure 3 below.

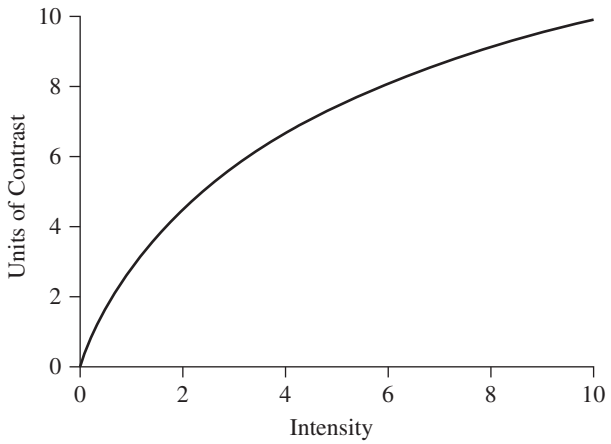


Figure 3. Contrast *vs*. intensity in brightness.

6. Given that "perceived contrast" can be calculated by taking the difference between two points on this line, the most reasonable interpretation of the data in Figure 3 is:

A. The perceived contrast doubles with every twofold increase in intensity.
B. In order to perceive the same contrast, a larger increase in intensity is need at higher intensities
C. No interpretation can be made, since the axes of the graph necessitate a semilog plot.
D. Intensity is directly related to perceived contrast.

LESSON 4.1, LEARNING GOAL 4:

- Use data to determine a study's conclusions and make predictions about the likelihood of future events

Conclusions and Predictions

Experiment 1
A researcher conducts an experiment to study reflex times and the integration of several sensory processes. In the study, participants have to catch a ball that has been dropped. As an approximation for reflex "speed," researchers measure how far the ball falls before the participant catches it. The data in Table 1 is obtained.

Participant	Age	Trial 1	Trial 2	Trial 3
1	25	13.3 cm	12.9 cm	11.6 cm
2	21	13.9 cm	13.6 cm	13.1 cm
3	24	13.6 cm	13.0 cm	12.1 cm
4	30	13.2 cm	13.0 cm	10.3 cm

Table 1. Results of three trials showing distances before participants caught the ball.

7. What can be concluded from this data?

A. Reaction time is positively correlated with age and positively correlated with attempt number.
B. Reaction time is positively correlated with age and negatively correlated with attempt number.
C. Reaction time is negatively correlated with age and positively correlated with attempt number.
D. Reaction time is negatively correlated with age and negatively correlated with attempt number.

8. The researcher repeats the reflex study above with a 17-year-old, Participant 5, and adds another trial. What should the researcher expect to be true about the value of the fourth trial of Participant 5?

A. The result of a fourth trial of Participant 5 is difficult to predict with the data given.
B. The result of Trial 4 should be a longer reaction time compared to other participants and previous trials.
C. The result should be a shorter reaction time compared to the other participants.
D. The reaction time would be unchanged from trial 3 to trial 4.

KAPLAN TIP
As you can see, data interpretation on Test Day is not just about the data; it's also about your ability to think critically about the data in front of you.

Experiment 2
A neuropsychologist is interested in finding out how a specific type of lesion in the reticular formation of the brain stem would affect how long a patient remained in a specific sleep stage. In order to test this, he invited six people with this type of lesion to participate in a simple sleep study. The researcher compared the time that each participant spent in different stages of sleep with that of their control counterparts. Results are shown in Figure 4.

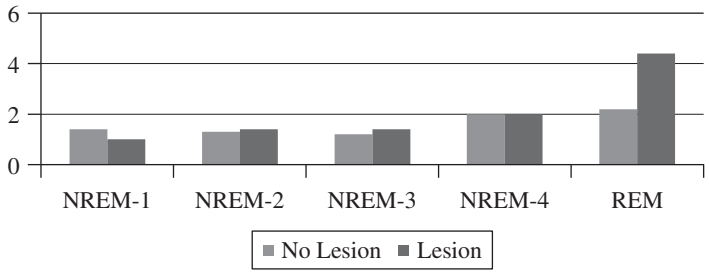


Figure 4. Time spent in stages of sleep for participants with and without the lesion.

9. Given the data above, what can you conclude about the sleep patterns in the two patient populations?

A. The patients with lesions spend more time in each NREM stage of sleep compared to the REM stage.
B. The patients without lesions spend an equal amount of time in each of the NREM sleep stages and double that time in the REM stage.
C. The patients with lesions showed no difference in their sleep patterns compared to their unaffected counterparts.
D. The patients with lesions spend about the same amount of time as unaffected patients in the NREM stages of sleep.

The neuropsychologist partnered with a neurobiologist during the study in order to measure the levels of specific neurotransmitters present throughout the different stages of sleep. The results for two of the neurotransmitters are shown in Figure 5.

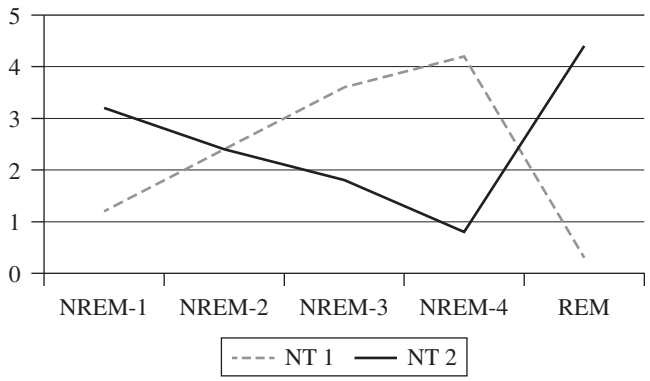


Figure 5. Levels of NT 1 and NT 2 in each sleep stage.

10. Assumeing that the neurobiologist was able to measure and depict levels of glutamate, which of the existing neurotransmitter patterns would it mirror?

A. NT 1, because it is an excitatory neurotransmitter that will be increased in the REM stage.
B. NT 1, because it is an inhibitory neurotransmitter that will be decreased in the REM stage.
C. NT 2, because it is an inhibitory neurotransmitter that will be decreased in the REM stage.
D. NT 2, because it is an excitatory neurotransmitter that will be increased in the REM stage.

LESSON 4.1 REVIEW

When Interpreting Data

- Look for overall trends
  - Are the data points increasing? decreasing? scattered?
- If asked to compare
  - Look for the widest gaps
  - Pay attention to axes and variables

Representation of Data

- A data set can be represented in more than one way.
- The representation of the data can be a clue to the questions that will be asked.
  - Table: Specific comparison/calculation
  - Line Graph: Progress of a variable over time
  - Bar Graph: Comparison of variables
  - Pie Chart: Part of a whole

Possible Relationship Between Variables

- Correlational
  - Positive: Directly related
  - Negative: Inversely related
  - None: Independent
- Causation
  - Rare, and requires a lot of experimental confirmation
- Curvilinear
  - Exponential: Positive with a limit
  - Logarithmic: Negative with a limit

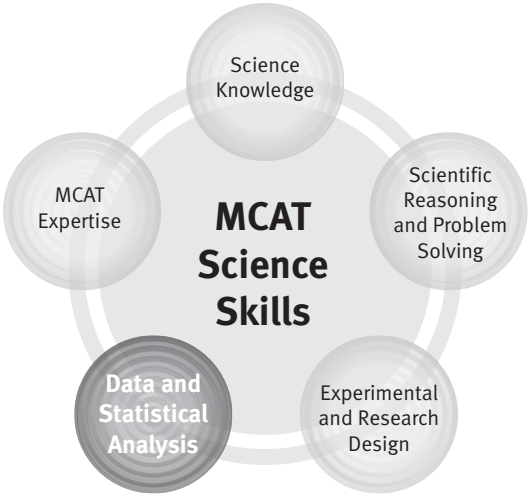
Data Distributions

In this lesson, you'll learn to:

- Use common measures of central tendency and dispersion to describe data
- Recognize anomalous data, given background information on the study in question

Science Topics:

- Associative Learning
- Memory



LESSON 4.2, LEARNING GOALS 1 AND 2:

- Use common measures of central tendency and dispersion to describe data
- Recognize anomalous data, given background information on the study in question

Data Distributions in Context—Practice Passage (Questions 1–7)

In studies of learning curves, the dependent variable is measured, while the independent variable is the experience of the learner. Experience is easily quantifiable; it can be measured in quantities such as hours studied or times through a maze. These values represent the amount of work done to enhance learning. To measure the effect of this experience, there must also be tests that show what effects the experience has on the skills of the subject.

One of the classical examples of quantifying learning and creating learning curves is running rats through a maze. Animal maze experiments began in the late 19th century and by the early 20th century rats became the standard model for animal testing. The design of animal mazes is simple: place a rat at an entrance point and allow it to find the exit point. Because some rats are faster than others, researchers normally keep track of how many dead ends ("mistakes") a rat runs into on its way to the exit, rather than the exact time taken for completion.

Running a rat through the same maze multiple times gives a learning curve. The experience variable is the number of times the rat has gone through the maze and the learning variable is the number of mistakes that it has made: the fewer mistakes, the more the rat has learned. A simple equation can be given to make the curve positive:

$$L = \frac{1}{(n+1)}$$

where n is the number of mistakes made in a given trial of the maze. Table 1 shows the number of mistakes made by each of five rats in an animal maze experiment.

Rat	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
1	11	11	8	9	7	5	4	3
2	13	9	7	4	5	4	3	2
3	15	11	11	9	7	5	5	4
4	10	11	10	9	8	7	6	2
5	15	13	11	9	7	6	11	4

Table 1. Results of eight trials in a maze-running experiment.

Passage Outline

P1.

P2.

P3.

Equation 1.

Table 1.

1. In the study described in the passage, what is the mean L for rats running through the maze for the fourth time?

A. $\frac{1}{10}$
B. $\frac{3}{25}$
C. 8
D. 9

2. If the data in Table 1 is standardized by removing the most mistake-filled run for each rat, how many modes does the standardized data have?

A. 0 modes
B. 1 mode
C. 2 modes
D. 3 or more modes

3. How does the standard deviation of mistakes per maze run change from trial 1 to trial 8?

A. There is less deviation and the standard deviation decreases from approximately 13 to approximately 3.
B. There is more deviation and the standard deviation increases from approximately 3 to approximately 13.
C. There is less deviation and the standard deviation decreases from approximately 4 to approximately 1.
D. There is more deviation and the standard deviation decreases from approximately 5 to approximately 2.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}}$$

Standard Deviation Formula

KAPLAN TIP

Exact calculations of the more complicated statistical variables, like standard deviation, will almost certainly NOT be necessary on the test. So if those calculations seem necessary, look for a better way!

Data Distributions in Context—Practice Passage (Questions 1–7)

In studies of learning curves, the dependent variable is measured, while the independent variable is the experience of the learner. Experience is easily quantifiable; it can be measured in quantities such as hours studied or times through a maze, These values represent the amount of work done to enhance learning. To measure the effect of this experience, there must also be tests that show what effects the experience has on the skills of the subject.

One of the classical examples of quantifying learning and creating learning curves is running rats through a maze. Animal maze experiments began in the late 19th century and by the early 20th century rats became the standard model for animal testing. The design of animal mazes is simple: place a rat at an entrance point and allow it to find the exit point. Because some rats are faster than others, researchers normally keep track of how many dead ends ("mistakes") a rat runs into on its way to the exit, rather than the exact time taken for completion.

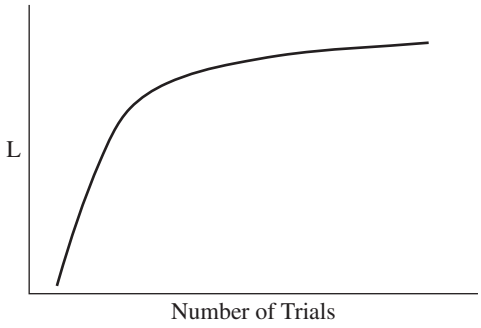
Running a rat through the same maze multiple times gives a learning curve. The experience variable is the number of times the rat has gone through the maze and the learning variable is the number of mistakes that it has made: the fewer mistakes, the more the rat has learned. A simple equation can be given to make the curve positive:

$$L = \frac{1}{(n+1)}$$

where n is the number of mistakes made in a given trial of the maze. Table 1 represents the data of an animal maze experiment with five rats, each of which had eight trials in the maze.

Rat	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
1	11	11	8	9	7	5	4	3
2	13	9	7	4	5	4	3	2
3	15	11	11	9	7	5	5	4
4	10	11	10	9	8	7	6	2
5	15	13	11	9	7	6	11	4

Table 1. Results of trials in a maze-running experiment.



4. How would the average slope of the learning curve for a longer, more complicated maze most likely differ from that of the curve for a shorter, less complicated maze?

A. It would be less steep, but *L* would have the same maximum value.
B. It would be steeper, but *L* would have a larger maximum value.
C. It would be less steep, but *L* would have a larger maximum value.
D. It would be steeper, but *L* would have a smaller maximum value.

5. Which rat has the lowest median for number of mistakes made throughout all eight trials?

A. Rat 1
B. Rat 2
C. Rat 3
D. Rat 4

6. What is the interquartile range for Rat 4's mistakes made?

A. 3.5
B. 5.6
C. 8
D. 11

7. Which of the following trials includes a significant outlier?

I. Trial 2
II. Trial 4
III. Trial 6
IV. Trial 7

A. I and II only
B. II and III only
C. II and IV only
D. II, III, and IV only

KAPLAN TIP
On Test Day, Skill 4 questions like this will be distributed across each science section, usually with one or two per passage.

LESSON 4.2 REVIEW

Key Concepts in Distributions (Centrality and Variance)

Mean

- Equals the sum of the values in a set divided by the number of values
- Often called the *"average"*

Median

- Equals the middle value in a set, when the items are ordered from least to greatest (or greatest to least)
- In sets with an even number of items, the median is the average of the middle *two* items

Mode

- The most commonly appearing value in a set
- *Bimodal* distributions have two "spikes" of common values

Standard Deviation

- Larger standard deviation means values are more spread out
- Standard deviation is the square root of the *variance* of a set

Quartiles

- Q_1, Q_2, Q_3, and Q_4 are the top ends of the first, second, third, and fourth quarter of a data set when the data is organized from least to greatest
- The *interquartile range* is the range between Q_1 and Q_3

Outliers

- Outliers are data points that are much larger or smaller than the other points in a data set, and are, by definition, not representative of the whole distribution
- Two common measures of outliers:
  - 1.5 or more standard deviations below or above Q_1 or Q_3, respectively
  - 4 or more standard deviations below or above the mean value of the set

Psychology and Sociology 1: Basic Science Research and Data

PASSAGE I (QUESTIONS 1–5)

Athletic skill level is an enigmatic topic due to the idea that it is often thought to come from a variety of origins. It can be thought of as an inborn talent, present from birth and discovered later, or a skill developed through hard work over time. Having athletic skills as an innate talent is regarded as a highly desirable trait. But determining cause-and-effect relationships having to do with athletic skill level is difficult, largely due to the multitude of factors that may be responsible alone or in combination. Having this athletic skill as an innate talent is highly desirable as well. Innate and inborn talent is associated with a person's genetic makeup and because of this, the question of the origin of athletic ability is a robustly researched topic in the scientific community. In cases like this, where genetic variation may play a role, researchers typically use sets of twins to isolate potential causal factors.

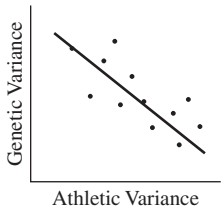
One such study sought to determine to what extent genetic variation leads to differences in overall athletic ability. The experimenters compared the relative athletic skill (as measured by sprinting speed, strength, and agility) of identical twins raised together, identical twins raised apart, and fraternal twins raised together. They then set their data next to the variability in athletic skill present in the general population. In analyzing their results, the researchers discovered a negative correlation between genetic relatedness and variance in athletic skill ($p = 0.07$).

1. Which of the following would be the most reasonable representation of the data described in the passage?

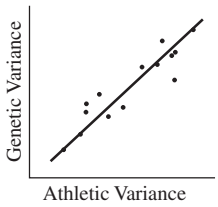
A. A pie chart
B. A scatterplot
C. A bar graph
D. A line graph

2. Based on the passage, which of the following graphs best represents the relationship between genetic variance and differences in athletic skill in the general population?

A.



B.



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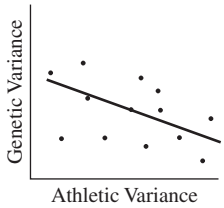
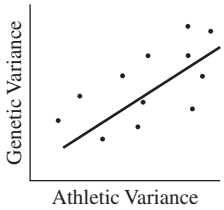


D.



3. Which of the following statements regarding the independent variables in the study is the most accurate?

A. They are examples of continuous variables, whereas the dependent variable is an example of a categorical variable.
B. They allow the researchers to control for environmental factors that might contribute to variability in athletic skill.
C. They are designed to be a reasonable, if ultimately incomplete, measure of the overall fitness of an individual.
D. They were measured directly by examining the genome of the participants for alleles known to be associated with athletic ability.

4. Suppose that a second group of researchers repeats the study and attains similar results, with a *p*-value of 0.03. Which of the following represents the most reasonable conclusion regarding this new result?

A. The original researchers made a mistake in their analysis of the data.
B. Genetic variance has been confirmed to cause differences in athletic ability.
C. The new study demonstrates a significant correlation that the original did not.
D. The second group of researchers must have had fewer outliers in their data set.

5. In a related study, researchers determine that parental encouragement of childhood athletic activity is more highly correlated with athletic ability later in life than is genetic variability. Based on these results, which of the following groups would be expected to have the highest variance in athletic ability?

A. Fraternal twins raised apart
B. Fraternal twins raised together
C. Identical twins raised apart
D. Identical twins raised together

PASSAGE II (QUESTIONS 1–7)

Hormonal chemistry plays a direct role in reinforcement learning, particularly in those cases in which a reward is unexpected. The pathway for reward learning is well documented: when an individual receives a reward that is unexpected, the event is encoded in the form of a release of dopamine targeting the ventral striatum and the prefrontal cortex. It is through the resultant activity that the individual becomes better at predicting future rewards. The pathway for fear-based learning is less clear, however. Recent studies have pointed to a decay in the response of the amygdala to sequential fear-inducing stimuli as well as an increase in serotonin activity following such events as a potential explanation for prediction error conditioning in fear learning.

Researchers wishing to investigate this pathway tested two groups in a Pavlovian learning task. Prior to testing, one of the two groups ate a protein-deficient diet in order to cause tryptophan deprivation (TRP^-), resulting in reduced serotonin activity. Researchers applied capsaicin to the forearms of members of both groups to induce increased sensitivity to temperature. Participants were presented with a stimulus consisting of a triangle shown either on the left or the right side of a display, and reaction times for determining on which side the triangle was shown were recorded. Eight seconds following the display of the visual stimulus, participants were sometimes subjected to a brief temperature increase to the capsaicin-treated area and sometimes were not. Skin conductance readings were taken four seconds after the presentation of the visual stimulus as a measure of autonomic fear response, and fMRI data was acquired.

Researchers discovered no significant difference in reaction times between the two groups. FMRI data showed increased activity in the orbitofrontal cortex and the amygdala for the control group. The TRP^- group demonstrated no such increase. Skin conductance results are shown in Figure 1.

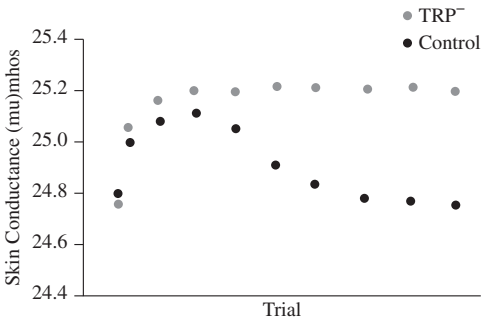


Figure 1. Skin conductance results.

As a final paper for an Introduction to Psychology course, a first-year college student runs an experiment based on the results of the experiment above. He reasons that since turkey meat contains tryptophan, and the fear response is at least partly related to increased heart rate, a large meal of turkey should have the opposite effect of the one noted in the original experiment. The student has several of his classmates record their resting pulse both before and after eating Thanksgiving dinner and other meals over the fall break. He then compares these results, as shown in Figure 2.

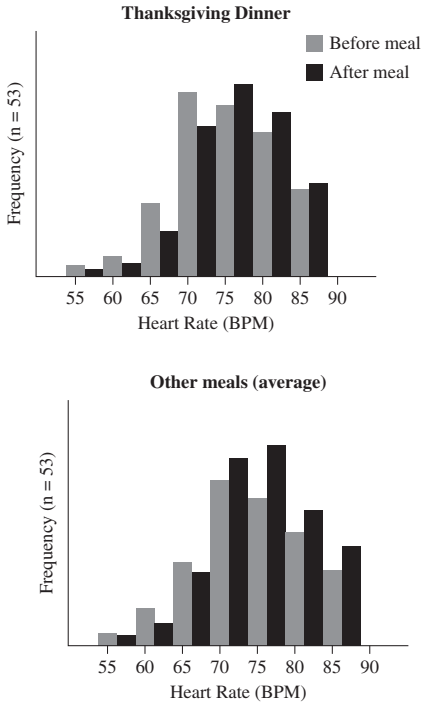


Figure 2. Pulse rates of classmates after eating meals.

1. Which of the following can be concluded on the basis of the researchers' study?

A. Tryptophan deprivation may be responsible for a disruption in the ability to learn from prediction errors in anticipation of a reward.
B. Suppression of serotonin pathways is correlated with a decrease in extinction of fear response to inconsistent stimuli.
C. Tryptophan deprivation negatively affects the ability of an individual to develop a fear response to a novel aversive stimulus.
D. Serotonin is largely responsible for the regulation of the physical and emotional aspects of the fear response to aversive stimuli.

2. Which of the following best describes the distribution in the student's results?

A. It is skewed to the left.
B. It is skewed to the right.
C. The average and the median are the same.
D. The standard deviation is larger on the left.

3. Which of the following can be concluded on the basis of the student's study?

A. Food consumption can be said to account, at least in part, for changes in resting heart rate.
B. The student's results show a significant difference in the dependent variable between conditions.
C. The student's results are inconsistent with the hypothesis with which he began.
D. Nothing can be reliably concluded because the student failed to operationalize his variables.

4. The student receives an "incomplete" and is asked to redo his paper and adhere more closely to the scientific method. Once the student decides on a new question to investigate, what should his next step include?

A. Forming a hypothesis
B. Reading previously published articles
C. Deciding on an experimental design
D. Applying for a research grant

5. Which of the following best describes the measurement of reaction time in the researchers' experiment?

A. It is a dependent variable.
B. It is an independent variable.
C. It is used as a control factor.
D. It was unnecessary.

6. Which of the following best describes the use of the capsaicin-enhanced temperature increase in the first study?

A. It is a punishment.
B. It is a negative reinforcer.
C. It is a conditioned stimulus.
D. It is an unconditioned stimulus.

7. Which of the following is NOT a testable scientific hypothesis?

A. Drug A is more effective than Drug B in reducing chemotherapy-induced nausea in cancer patients.
B. Drug A is more effective than a placebo in reducing the number of panic attacks in patients with GAD.
C. Drug A generally reduces the intensity of auditory hallucinations in patients diagnosed with schizophrenia.
D. Drug A is the best remedy to reduce both the severity and the intensity of a migraine headache.

PASSAGE III (QUESTIONS 1–6)

Color constancy is the term given to the phenomenon that an object's perceived color remains relatively unchanged under varying conditions of illumination. As a result, an object appears to be the same color after a change in illumination, even though the absolute wavelength of the light the object reflects has changed. It has been hypothesized that the mechanism for color constancy in the brain is optimized for natural light due to its evolution under such conditions.

To test this hypothesis, a study is conducted in which participants were presented with a scene containing real objects, which varied between trials. Sets of objects included various fruits and three-dimensional paper cutouts with the same surface color as the fruits. Each participant was first presented with a scene under a target illumination of a specific wavelength. Participants were then presented with the same scene under two test illuminations: one that matched the original and one that was different. Participants were asked to determine which one matched the original illumination. Illumination conditions varied along two loci. The daylight locus (u) corresponds roughly to changes in natural illumination throughout the day and is associated with the blue-yellow spectrum, with blue being the most common daylight illumination. A perpendicular atypical locus (v) corresponds to wavelengths on the red-green spectrum, typically seen only under artificial conditions, with green being the least common illumination in natural conditions.

In analyzing their results, researchers discovered that the contents of the scene had no significant effect on participants' accuracy in color matching. Results are provided in Figure 1.

Researchers then plotted a curve around the point marking a neutral illumination level in both the u and v loci. This curve marks the boundary for which participants attained a 75 percent accuracy rate in discriminating from the neutral illumination, and is presented in Figures 2 and 3.

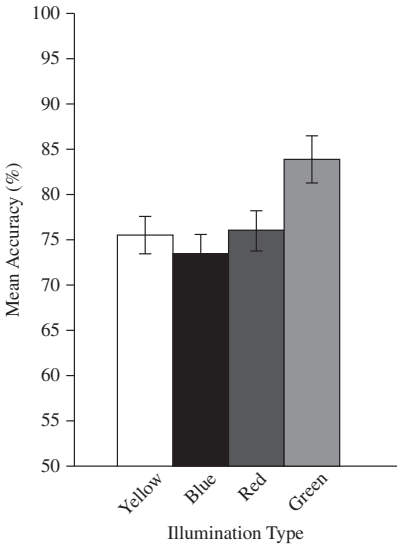


Figure 1. Effect of illumination type on color matching.

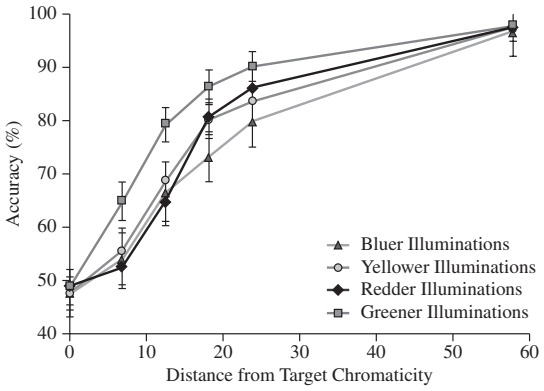


Figure 2. Distance from target chromaticity versus accuracy.

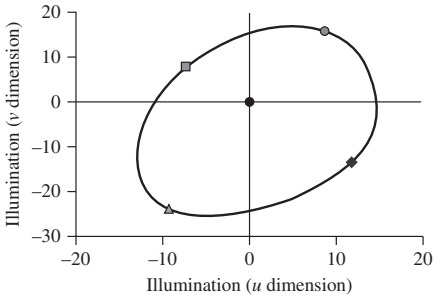


Figure 3. Illumination curve.

1. Which of the following is a potential problem with the design of the study as described?

A. The researchers' hypothesis, as stated, cannot be feasibly investigated.
B. The design of the experiment does not actually test the quantitative aspects of the hypothesis.
C. The experiment has no practical benefit, and is therefore not relevant.
D. Researchers failed to control for absolute differences in perception between participants.

2. Which of the following best summarizes a conclusion that can be made on the basis of the experiment?

A. Evolutionary processes can be said to be responsible, at least in part, for the mechanisms responsible for color constancy.
B. The color constancy effect is strongest under artificial lighting conditions and weakest under natural lighting conditions.
C. The color constancy effect is strongest under natural lighting conditions and weakest under artificial lighting conditions.
D. Color constancy has been shown to be mostly unrelated to lighting conditions as measured under both natural and artificial conditions.

3. Which of the following structures is/are most likely responsible for the phenomenon of color constancy?

A. The primary visual cortex
B. The cone cells of the retina
C. The superior colliculus
D. The lateral geniculate nucleus

4. For which of the following points on the illumination chart would participants be expected to demonstrate the highest accuracy of discrimination as compared to the neutral illumination?

A. $u = -5, v = +10$
B. $u = +8, v = -5$
C. $u = +10, v = +10$
D. $u = -15, v = -25$

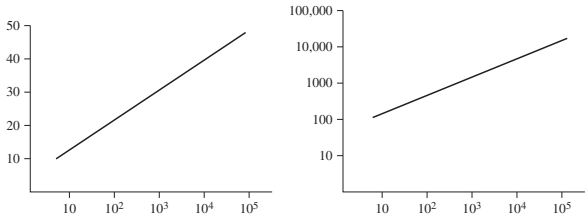
5. The researchers determine that the point $u = -1$, $v = +3$ is well within the just-noticeable difference threshold for the neutral illumination. What is the expected accuracy for the discrimination task at this point?

A. 0%
B. 25%
C. 50%
D. 75%

6. Which of the following best expresses the purpose of the experiment?

A. To determine the extent to which variations in natural and artificial light predict accuracy of color constancy
B. To show that the mechanisms of color constancy evolved under pressure of natural selection in situ
C. To demonstrate that natural light should be preferred over artificial sources when designing interior spaces
D. To prove that artificial light makes it more difficult to discriminate between the colors of objects

DISCRETE PRACTICE QUESTIONS (QUESTIONS 1–6)



1. Which of the following best describes the graphs above?

A. Both graphs show a linear relationship.
B. The first graph is a log-log plot; the second is a semi-log plot.
C. The first graph is a semi-log plot; the second is a log-log plot.
D. Both graphs show an exponential relationship.

Questions 2–4 are based on the following data set:

Number of Nonsense Words Memorized

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Participant 1	4	5	4	8	6	8	9	8	9
Participant 2	6	7	7	6	7	9	10	9	9
Participant 3	4	3	5	4	8	6	6	13	9
Participant 4	5	6	5	5	6	7	7	8	7

2. Which of the participants has the lowest standard deviation?

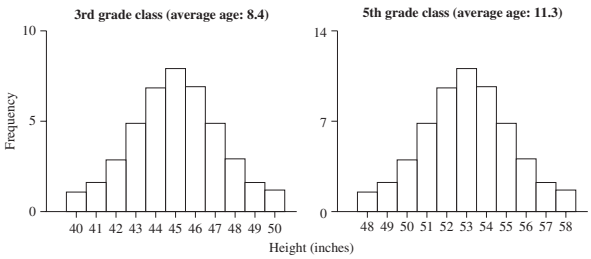
A. Participant 1
B. Participant 2
C. Participant 3
D. Participant 4

3. Which of the following is an accurate comparison between the results for participants 1 and 2?

A. Participant 1 has a lower median and a lower mean.
B. Participant 1 has a lower median and a higher mean.
C. Participant 1 has a higher median and a lower mean.
D. Participant 1 has a higher median and a higher mean.

4. Should Trial 8 for Participant 3 be removed as an outlier?

A. Yes, because it is more than two standard deviations from the mean.
B. Yes, because it is more than 1.5 interquartile ranges from Q_3.
C. No, because it is within 1.5 interquartile ranges from Q_3.
D. No, because removing data decreases the validity of a study.



5. If the information in the above graphs were combined into one data set, which of the following would accurately describe the result?

A. The standard deviation of the combined graph would be double that of the original graphs.
B. The mean of the combined graph would remain the same as the mean in the original graphs.
C. The value of *n* at each point would increase, but other statistical measures would remain largely unaffected.
D. The combination would result in a different average and standard deviation, and the graph would be bimodal.

6. A researcher hypothesizes that altering the gravitational constant of the universe would change the height from which rats can be dropped without sustaining injury. This hypothesis violates each of the following principles of experimental design EXCEPT:

A. Feasible
B. Interesting
C. Ethical
D. Relevant