RATIOMERA

Exercise Sheet

Covariance and Correlation

Ratiomera Statistics

This sheet contains 70 exercises organized into 7 learning-objective groups. Work through each exercise before consulting its matching complete solution. Show the relevant formula or rule, substituted values, units, and an interpretation. All settings, values, data, and software outputs are constructed teaching material; they are not empirical findings.

Part I: Theory

A02: Third Variables and the Boundary of Causal Claims

`T04-A02-V01`: Library visits and course marks

In an invented teaching scenario, a hypothetical study reports a correlation between weekly library visits and course marks. (a) Explain how study motivation and course workload could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

`T04-A02-V02`: Park access and neighborhood trust

In an invented teaching scenario, a hypothetical study reports a correlation between nearby park space and average trust. (a) Explain how neighborhood income and public investment could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

`T04-A02-V03`: Remote work and volunteer hours

In an invented teaching scenario, a hypothetical study reports a correlation between remote-work frequency and volunteer hours. (a) Explain how schedule flexibility and occupation could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

`T04-A02-V04`: Museum membership and cultural participation

In an invented teaching scenario, a hypothetical study reports a correlation between museum membership and cultural-event attendance. (a) Explain how prior interest in cultural activities could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

`T04-A02-V05`: Cycling lanes and retail visits

In an invented teaching scenario, a hypothetical study reports a correlation between protected cycling infrastructure and weekend shop visits. (a) Explain how street centrality and store mix could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

T04-A02-V06: Caption availability and course completion

In an invented teaching scenario, a hypothetical study reports a correlation between caption availability and course completion. (a) Explain how course production quality and subject area could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

T04-A02-V07: Garden plots and wellbeing

In an invented teaching scenario, a hypothetical study reports a correlation between community-garden participation and wellbeing. (a) Explain how baseline health and social connection could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

T04-A02-V08: Transit use and daily activity

In an invented teaching scenario, a hypothetical study reports a correlation between public-transit use and daily step count. (a) Explain how urban density and car access could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

T04-A02-V09: Music lessons and memory

In an invented teaching scenario, a hypothetical study reports a correlation between years of music lessons and memory score. (a) Explain how family resources and educational support could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

T04-A02-V10: Online discussion and exam performance

In an invented teaching scenario, a hypothetical study reports a correlation between discussion-board posts and exam score. (a) Explain how prior understanding and engagement could act as a third variable. (b) Draw or describe a three-variable diagram with arrows that represents this explanation. (c) State what the hypothetical correlation does and does not establish. (d) Propose a stronger design or analysis without pretending that statistical adjustment creates random assignment.

A07: Diagnosing Association and Causal Claims

T04-A07-V01: Puzzle apps and navigation

The following report is invented solely for this teaching exercise; it is not an empirical claim: A one-time volunteer survey finds that puzzle-app users report better navigation than nonusers and concludes that the app creates navigation ability. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

T04-A07-V02: Parks and individual trust

The following report is invented solely for this teaching exercise; it is not an empirical claim: Districts with more parks have higher average trust, so a report claims that adding one park will make every resident more trusting. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V03`: Blue notebooks and memory

The following report is invented solely for this teaching exercise; it is not an empirical claim: An online poll reports higher self-reported grades among people choosing blue notebooks and says blue paper improves memory. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V04`: Remote work and volunteering

The following report is invented solely for this teaching exercise; it is not an empirical claim: Employees who choose remote work report more volunteer hours, and a blog says remote work produces civic responsibility. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V05`: Morning markets and diet

The following report is invented solely for this teaching exercise; it is not an empirical claim: Towns with morning markets have higher household dietary-variety averages, and a report claims that attending a market improves every household's diet. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V06`: Digital reminders and attendance

The following report is invented solely for this teaching exercise; it is not an empirical claim: Clinic attendance rose from 69% to 77% after reminders were introduced, without a concurrent comparison group, and the clinic attributes the full change to reminders. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V07`: Poetry clubs and empathy

The following report is invented solely for this teaching exercise; it is not an empirical claim: Poetry-club members report higher empathy than an unrelated online benchmark, and a feature claims club membership produces empathy. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V08`: Cycle lanes and retail traffic

The following report is invented solely for this teaching exercise; it is not an empirical claim: Streets with cycle lanes receive more weekend visits, and an association says adding lanes will produce the entire observed difference. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V09`: Garden plots and wellbeing

The following report is invented solely for this teaching exercise; it is not an empirical claim: Plot renters report greater wellbeing than people on a waiting list, and a release says gardening cures low wellbeing. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

`T04-A07-V10`: Captioned courses and completion

The following report is invented solely for this teaching exercise; it is not an empirical claim: Courses offering captions have higher completion averages, and a platform says captions alone cause persistence. (a) Identify the observational units and whether the claim is individual-level or aggregate. (b) List at least three specific threats involving measurement, sampling, time order, aggregation, or third variables. (c) Rewrite the result as a defensible association statement. (d) Propose evidence that would address the causal question more credibly.

Part II: Calculator Practice

A01: Pearson Correlation and Hidden Nonlinearity

`T04-A01-V01`: Background sound and proofreading errors

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (1, 2, 3, 4, 5, 6, 7)$ for background-sound setting in coded units and $Y = (11, 6, 3, 2, 3, 6, 11)$ for proofreading errors. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V02`: Room temperature and concentration loss

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (19, 20, 21, 22, 23, 24, 25)$ for room temperature in degrees Celsius and $Y = (20, 10, 4, 2, 4, 10, 20)$ for concentration-loss score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V03`: Daily practice and fatigue at both extremes

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (1, 2, 3, 4, 5, 6, 7)$ for daily practice time in hours and $Y = (11, 6, 3, 2, 3, 6, 11)$ for fatigue score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V04`: Museum crowding and visit discomfort

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (1, 2, 3, 4, 5, 6, 7)$ for museum-crowding score and $Y = (29, 14, 5, 2, 5, 14, 29)$ for discomfort rating. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V05`: Text size and reading difficulty

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (9, 10, 11, 12, 13, 14, 15)$ for text size in typographic points and $Y = (20, 10, 4, 2, 4, 10, 20)$ for reading-difficulty score. (a) Calculate both means, the cross-product sum $\sum(x_i -$

$\bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V06`: Notification frequency and task disruption

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (0, 1, 2, 3, 4, 5, 6)$ for notifications per hour and $Y = (11, 6, 3, 2, 3, 6, 11)$ for disruption score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V07`: Route complexity and navigation strain

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (2, 3, 4, 5, 6, 7, 8)$ for route-complexity score and $Y = (29, 14, 5, 2, 5, 14, 29)$ for navigation-strain score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V08`: Session length and restlessness

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (3, 4, 5, 6, 7, 8, 9)$ for session length in ten-minute units and $Y = (11, 6, 3, 2, 3, 6, 11)$ for restlessness score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V09`: Archive humidity and preservation risk

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (2, 3, 4, 5, 6, 7, 8)$ for relative humidity in ten-percentage-point units and $Y = (20, 10, 4, 2, 4, 10, 20)$ for preservation-risk score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

`T04-A01-V10`: Lighting intensity and visual discomfort

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Seven constructed cases give $X = (1, 2, 3, 4, 5, 6, 7)$ for lighting intensity in coded units and $Y = (20, 10, 4, 2, 4, 10, 20)$ for visual-discomfort score. (a) Calculate both means, the cross-product sum $\sum(x_i - \bar{x})(y_i - \bar{y})$, and Pearson's r. (b) Describe the pattern you would see in a scatterplot. (c) Explain why a coefficient near zero does not mean that the two variables are unrelated in every sense.

A03: Testing a Directional Population Correlation

`T04-A03-V01`: Practice time and reasoning score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 20$ gives sample standard deviations $s_x = 2.00$ and $s_y = 5.00$ and sample covariance $s_{xy} = 4.1000$ for weekly practice hours and reasoning score. Before seeing the values, the directional alternative was specified as $H_1 : \rho > 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary +1.7341 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V02`: Search time and archive accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 25$ gives sample standard deviations $s_x = 4.00$ and $s_y = 3.00$ and sample covariance $s_{xy} = -4.3200$ for search time and accuracy score. Before seeing the values, the directional alternative was specified as $H_1 : \rho < 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary −1.7139 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V03`: Reading time and comprehension

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 30$ gives sample standard deviations $s_x = 2.50$ and $s_y = 8.00$ and sample covariance $s_{xy} = 5.6000$ for reading time and comprehension score. Before seeing the values, the directional alternative was specified as $H_1 : \rho > 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary +1.7011 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V04`: Navigation errors and route confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 35$ gives sample standard deviations $s_x = 3.00$ and $s_y = 6.00$ and sample covariance $s_{xy} = -5.9400$ for navigation-error count and route-confidence score. Before seeing the values, the directional alternative was specified as $H_1 : \rho < 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary −1.6924 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V05`: Workshop attendance and concept score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 40$ gives sample standard deviations $s_x = 1.50$ and $s_y = 10.00$ and sample covariance $s_{xy} = 3.6000$ for sessions attended and concept score. Before seeing the values, the directional alternative was specified as $H_1 : \rho > 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary +1.6860 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V06`: Notification count and focus rating

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 45$ gives sample standard deviations $s_x = 5.00$ and $s_y = 2.00$ and sample covariance $s_{xy} = -2.2000$ for daily notifications and focus rating. Before seeing the values, the directional alternative was specified as $H_1 : \rho < 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary −1.6811 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V07`: Museum visits and historical knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 50$ gives sample standard deviations $s_x = 2.00$ and $s_y = 7.00$ and sample covariance $s_{xy} = 2.8000$ for museum visits and knowledge score. Before seeing the values, the directional alternative was specified as $H_1 : \rho > 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary +1.6772 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V08`: Response delay and satisfaction

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 60$ gives sample standard deviations $s_x = 4.00$ and $s_y = 4.00$ and sample covariance $s_{xy} = -2.8800$ for response delay and satisfaction score. Before seeing the values, the directional alternative was specified as $H_1 : \rho < 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary −1.6716 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V09`: Practice sets and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 80$ gives sample standard deviations $s_x = 3.00$ and $s_y = 5.00$ and sample covariance $s_{xy} = 2.5500$ for practice sets completed and confidence score. Before seeing the values, the directional alternative was specified as $H_1 : \rho > 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary +1.6646 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

`T04-A03-V10`: Route familiarity and travel time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

A hypothetical sample of $n = 100$ gives sample standard deviations $s_x = 6.00$ and $s_y = 2.50$ and sample covariance $s_{xy} = -2.1000$ for route-familiarity score and travel time. Before seeing the values, the directional alternative was specified as $H_1 : \rho < 0$. (a) Calculate Pearson's $r = s_{xy}/(s_x s_y)$ and state H_0. (b) Calculate $t = r\sqrt{(n-2)/(1-r^2)}$ with $df = n - 2$. (c) Use the one-sided 5% boundary −1.6606 to decide. (d) Interpret the sign, strength, statistical evidence, and practical importance separately.

A04: Spearman Correlation from Separate Ranks

`T04-A04-V01`: Reading frequency and vocabulary rank

The same 6 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6)$ and $R_Y = (1, 3, 2, 5, 4, 6)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6\sum d_i^2/[n(n^2-1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

`T04-A04-V02`: Search efficiency and accuracy rank

The same 7 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6, 7)$ and $R_Y = (2, 1, 4, 3, 6, 5, 7)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6\sum d_i^2/[n(n^2-1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V03: Practice rank and reasoning rank

The same 6 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6)$ and $R_Y = (1, 2, 4, 3, 6, 5)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V04: Attendance rank and confidence rank

The same 7 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6, 7)$ and $R_Y = (1, 3, 2, 4, 6, 7, 5)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V05: Navigation skill and error rank

The same 6 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6)$ and $R_Y = (6, 5, 3, 4, 2, 1)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V06: Response-delay and satisfaction rank

The same 7 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6, 7)$ and $R_Y = (7, 5, 6, 4, 3, 1, 2)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V07: Museum visits and knowledge rank

The same 6 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6)$ and $R_Y = (2, 1, 3, 5, 4, 6)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V08: Practice regularity and retention rank

The same 7 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6, 7)$ and $R_Y = (1, 2, 4, 3, 5, 7, 6)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V09: Task switching and focus rank

The same 6 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6)$ and $R_Y = (5, 6, 4, 3, 1, 2)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

T04-A04-V10: Archive experience and search rank

The same 7 cases have rank vectors $R_X = (1, 2, 3, 4, 5, 6, 7)$ and $R_Y = (1, 3, 2, 5, 4, 7, 6)$, where rank 1 is the smallest value for each variable. (a) Calculate each difference $d_i = R_{Xi} - R_{Yi}$ and $\sum d_i^2$. (b) Use $r_s = 1 - 6 \sum d_i^2 / [n(n^2 - 1)]$. (c) Interpret the sign and magnitude as a monotonic rank association, not as a difference in measurement units.

A05: Pearson and Spearman under Monotonic Curvature

T04-A05-V01: Practice hours and fluent-recall score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (2, 3, 5, 8, 12, 17, 23)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V02: Archive experience and retrieval speed

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (70, 53, 41, 32, 26, 22, 19)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V03: Museum visits and knowledge score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (10, 13, 17, 22, 28, 35, 43)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V04: Route familiarity and navigation time

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (65, 48, 37, 29, 24, 20, 17)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V05: Practice sets and confidence score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (20, 22, 25, 29, 34, 40, 47)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V06: Notification load and focus score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (82, 69, 59, 51, 45, 40, 36)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

T04-A05-V07: Reading sessions and vocabulary score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (30, 31, 34, 39, 46, 55, 66)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

`T04-A05-V08`: Search attempts and remaining errors

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (24, 18, 14, 11, 9, 8, 7)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

`T04-A05-V09`: Workshop sessions and reasoning score

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (40, 43, 47, 52, 58, 65, 73)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

`T04-A05-V10`: Route complexity and completion rate

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Constructed values are $X = (1, 2, 3, 4, 5, 6, 7)$ and $Y = (95, 83, 72, 62, 53, 45, 38)$. (a) Sketch the point pattern or describe its direction and curvature. (b) Calculate Pearson's r from the original values. (c) Rank both variables and calculate Spearman's r_s. (d) Explain why the coefficients differ even though both variables move monotonically.

A06: Spearman Correlation with Ties and Positive Transformations

`T04-A06-V01`: Practice days and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 1, 2, 3, 3, 4, 5, 5)$ and $Y = (42, 45, 45, 51, 54, 54, 60, 63)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^* = 5 + 2Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V02`: Museum visits and knowledge

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (0, 1, 1, 2, 3, 3, 4, 4)$ and $Y = (30, 34, 36, 36, 41, 45, 45, 48)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^* = 7 + 3Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V03`: Archive shifts and retrieval skill

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 2, 2, 2, 3, 4, 4, 5)$ and $Y = (18, 21, 21, 24, 27, 27, 30, 33)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b)

Transform the second variable to $Y^{*} = 4 + 2Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V04`: Reading sessions and recall

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (2, 2, 3, 4, 4, 5, 6, 6)$ and $Y = (50, 50, 55, 59, 62, 62, 68, 71)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 3 + 4Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V05`: Route attempts and accuracy

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 1, 2, 2, 3, 4, 5, 5)$ and $Y = (61, 64, 64, 68, 72, 72, 77, 80)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 6 + 2Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V06`: Workshop attendance and reasoning

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (0, 1, 1, 2, 2, 3, 4, 4)$ and $Y = (35, 39, 42, 42, 47, 50, 50, 54)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 8 + 3Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V07`: Practice sets and fluency

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 2, 2, 3, 4, 4, 5, 5)$ and $Y = (44, 47, 47, 52, 56, 59, 59, 63)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 2 + 5Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V08`: Search experience and speed

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 1, 2, 3, 3, 4, 4, 5)$ and $Y = (75, 69, 69, 62, 58, 58, 53, 49)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 100 + 2Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

`T04-A06-V09`: Discussion posts and confidence

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (0, 1, 1, 2, 3, 3, 4, 5)$ and $Y = (40, 43, 46, 46, 51, 55, 55, 59)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^{*} = 9 + 2Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.

RATIOMERA

T04-A06-V10: Navigation practice and errors

Reason first. Before calculating, state the relationship, rule, or expected pattern that makes the calculation appropriate.

Eight cases have $X = (1, 2, 2, 3, 3, 4, 5, 5)$ and $Y = (18, 16, 16, 13, 11, 11, 8, 6)$. (a) Assign average ranks to every tied block and calculate Spearman's correlation as the Pearson correlation of the two rank columns. (b) Transform the second variable to $Y^* = 20 + 3Y$. Explain before recalculating whether the ranks and r_s should change. (c) State what would be different if the multiplier were negative.