

Bias, error, graph choice

Your goal: Identify sources of bias and error and choose the right graph for your physiology data.

One product: Draft graph showing the physiology comparison with labeled axes, units, a title, and an annotated bias-and-error note.

Question: Which graph fits the actual comparison, and what bias or measurement error could change its interpretation?

Start the work

1. List possible sources of bias and measurement error in your study.
2. Decide which graph type best shows your comparison.
3. Draft the graph with labeled axes and units.
4. Note how bias or error could affect what the graph shows.
5. Submit your graph draft with a bias-and-error note.

Save the same work when access is missing. Identify what you need separately for the spreadsheet/upload, actual-data and official requirements. A paper or S1 recovery graph does not establish those branches as complete.

Words you will use

physiology

How living bodies function.

condition

A situation or group being compared.

bias

A systematic influence that can push an estimate or conclusion away from its target.

measurement error

A difference between a measured value and its reference or target value; it can have systematic and random components.

systematic error

A consistent shift associated with a measurement process.

random variation

Unpredictable differences across observations; not all variation is measurement error.

order effect

A change related to which condition or measurement came first.

confounding

Two possible explanations vary together, so their separate effects cannot be resolved by that comparison.

calibration

Checking a device against a known reference using an approved procedure.

raw data

Recorded values before averaging or other summaries.

independent observations

Records that are not repeated measurements of the same unit or otherwise linked by the design.

paired data

Two values linked to the same participant or other unit.

mean

Sum of values divided by their count.

median

Middle ordered value, or mean of the two middle values when the count is even.

quartiles

Values marking the lower and upper quarters of ordered data; calculation conventions can differ.

distribution

How values are spread across their range.

bar graph

A graph using lengths from a baseline to compare values for separate categories.

line graph

A graph connecting points to show a meaningful sequence or relationship; the connection must have a stated meaning.

scatter plot

A graph placing paired numerical x and y values as points to show their relationship.

box plot

A graph summarizing a distribution with its median, quartiles and a stated whisker rule.

dot plot

A graph showing individual values as dots, with stacks when values repeat.

axis / axes

A reference line or lines that locate values on a graph.

baseline

The value from which a bar or area begins.

units

The stated measurement scale, such as beats per minute.

bpm

Beats per minute, the unit used for pulse rate in S1.

annotation

A note attached to a graph explaining a relevant feature or limitation.

validity

How well evidence supports its intended interpretation.

outlier

A value unusually far from others; not automatically an error.

statistical significance

A judgment under a specified statistical model and threshold; visible separation alone does not establish it.

standard deviation

A measure of spread around the mean.

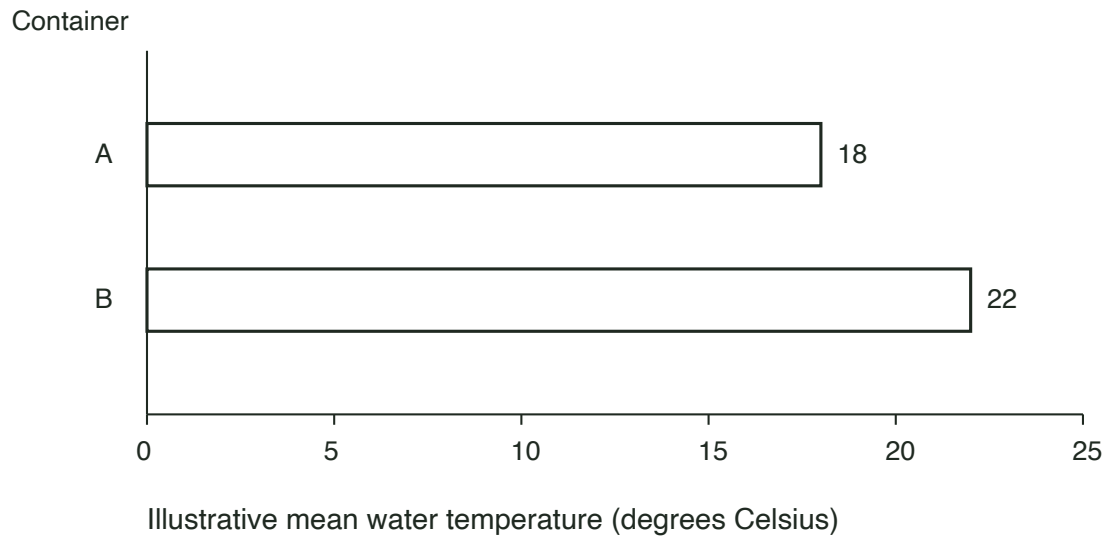
replication

Repeating an investigation to examine whether findings hold.

V1: Separate container means

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Original teaching example. Invented values, not observations.



Original teaching example. Invented values, not observations. Read the full text equivalent in G1.

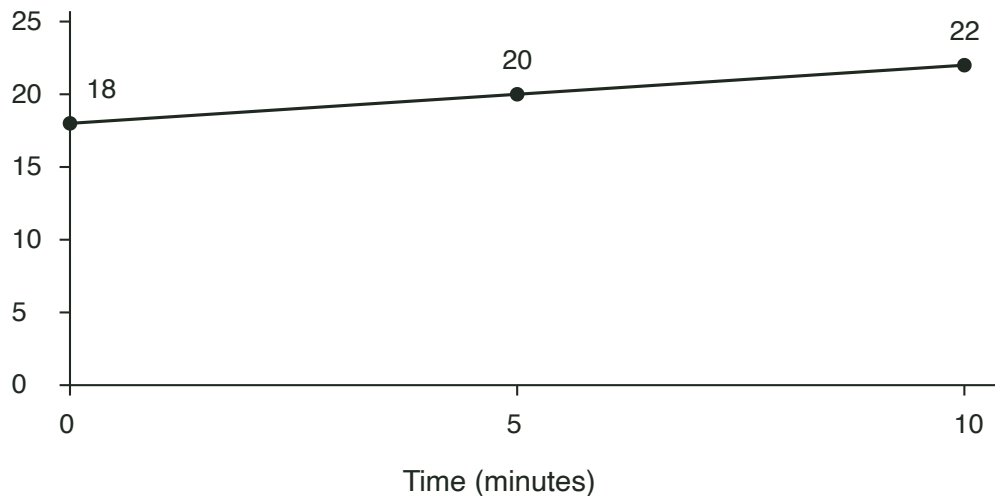
Text description: Two horizontal bars from zero: container A,18 degrees Celsius; container B,22. Value axis zero to25.

V2: One sample over time

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Original teaching example. Invented values, not observations.

Temperature (degrees Celsius)



Original teaching example. Invented values, not observations. Read the full text equivalent in G1.

Text description: Connected points at 0,5,10 minutes with 18,20,22 degrees Celsius. Temperature axis zero to 25.

E1: bias and measurement error can overlap

NIST treats measurement bias as systematic error in its measurement handbook. It also discusses variation associated with operators, instruments and conditions. Do not sort every problem into bias OR error as if the categories never overlap.

A fictional device reading four units high would shift recorded levels. If the same shift affected both conditions equally, it would not necessarily change their difference. If only one condition used that device, the gap could be distorted. This is an invented illustration, not a diagnosis of your instrument.

If everyone completed condition A before B, practice, elapsed time or fatigue could be alternative explanations for a difference. Their presence and direction must be investigated, not assumed. Write a possible study-specific source, the part of the process involved and what it could affect. More observations do not automatically remove a systematic problem.

E2: choose the graph for the question

For two separate condition means, use bars or columns from zero and label what each summary represents. Bar length encodes value, so cutting its baseline can exaggerate the apparent difference. ONS distinguishes this from point and line displays, where a clearly labeled nonzero scale can be appropriate.

For change over measured time, a line can connect the observations in time order. For a relationship between two numerical variables, a scatter plot displays paired x/y values. NIST notes that an association alone does not establish cause.

For group distributions, a box plot shows the median and middle half of the values. State its whisker convention and retain raw values when possible. NIST describes both minimum/maximum whiskers and a convention that marks extreme values separately.

A mean-only bar hides individual spread. Retain the raw table or add dots when the task requires that spread. A line across separate means can imply an unsupported sequence. Lines linking each participant's paired measurements can have a valid meaning if that pairing is explicit. Do not invent pairing or time points.

G1: two supplied graph inputs and what they claim

Inspect the supplied V1-bar.svg and V2-line.svg teaching figures before your own graph. Both show invented non-biomedical examples, not observed experiments. Say aloud or write what each display compares. If the images are not displayed, report the missing visual input; the descriptions below remain available for access.

V1-bar shows two separate insulated containers, A and B. Their illustrative mean water temperatures are 18 and 22 degrees Celsius. Two horizontal bars start at zero on a 0-to-25 value axis. The category axis names the containers. This display compares separate category means, not a time sequence.

V2-line shows one illustrative sample over time. Its values are 18, 20 and 22 degrees Celsius at 0, 5 and 10 minutes. Points are joined in time order. The horizontal axis is time in minutes; the vertical axis spans 0 to 25 degrees Celsius. This display represents change within the stated sequence; it proves no cause.

Warmup one: explain when zero is needed and how the baseline changes visible bar length. Warmup two: name one possible order effect and explain how it could nudge a comparison. Use a hypothetical example if actual collection details are missing.

S1: original recovery data and study description

Use the actual approved dataset and collection record when available. S1 is a complete instructional substitute for practice only, not observed student data or the weekly assigned dataset. It authorizes no exercise, posture change, sensor use or new collection.

Recovery question: how do the supplied pulse-rate distributions compare between condition A and condition B? All values below are invented in beats per minute. Each column represents four separate hypothetical records. A displayed row does not link the two columns to the same person.

Two-column values, A | B: row 1, 72 | 76; row 2, 76 | 80; row 3, 80 | 84; row 4, 84 | 88. Each column has four values. A sums to 312 and has mean 78 bpm. B sums to 328 and has mean 82 bpm. The mean difference B minus A is 4 bpm.

Invented collection description: all A records were scheduled before all B records; the operator did not record device-reference checks or exact reading times. Decide which of these details could raise a bias or measurement concern. They do not prove fatigue, faulty calibration or the direction of an error. No known true pulse values are supplied.

For S1, decide whether the recovery question is best answered by comparing the two means or the two distributions, choose the matching display from E2 and justify the choice. Retain all raw values in the same record. No significance test or causal effect is established by these eight invented values.

R1: complete plotting inputs and procedures

For S1 mean bars, use title Original practice: pulse-rate means for conditions A and B. Label categories A and B and the value axis Mean pulse rate (bpm). Use a 0-to-100 scale in equal steps of 20 and bar lengths of 78 and 82. Preserve the S1 raw table so spread is not hidden.

For a S1 dot display, label the value axis Pulse rate (bpm) and the category axis A/B. Mark all four raw values per condition using a common clearly labeled 60-to-100 scale in steps of 10. State that this is a point display with a nonzero scale. Do not connect the two columns as matched participants.

For a S1 box plot using the median-of-halves convention: A has minimum 72, lower quartile 74, median 78, upper quartile 82 and maximum 84. B has 76, 78, 82, 86 and 88. Use minimum/maximum whiskers, state that rule, and use a common 60-to-100 value scale. These summaries were calculated from S1, not measured separately.

For actual data, first identify categories or numerical x-values, outcome units and whether records are paired. Select a graph that fits that structure; do not force the S1 template onto a different design. Keep legitimate values, label any missing entries, and ask before excluding data.

Spreadsheet recovery route: enter A and B headers with bpm units, then the four S1 rows. For means, calculate each column's sum divided by four, or use the spreadsheet's average function. Build a two-category summary table with 78 and 82; select that table and insert bars or columns.

Set the value-axis minimum to zero and maximum to 100, add title and axis labels, and compare every plotted value with the table. Save the spreadsheet graph and note together. Menu names depend on the available application. If software is absent, a paper draft is preparation; ask how to complete the assigned spreadsheet and upload.

C1: annotation, self-check and extension

Attach a two-line note: name one possible bias source and its effect on interpretation; then name one measurement-error source and its possible effect. If a source overlaps both categories, explain the overlap. Use could when its existence or direction has not been measured.

For S1, find the details in the collection description that could produce a possible bias and a possible measurement error, and state what each does and does not establish. Explain why the drawn gap alone cannot separate these possibilities. For your actual data, use its actual process details without personal identifiers.

Self-check: for separate mean heart rates labeled rest and after exercise, decide which display fits the stated summary and whether it is a measured time series. An explicitly paired display stays possible when the actual data support one. No exercise is requested.

Extension: draw the same comparison twice, once honestly and once deliberately misleading. Mark the second Teaching counterexample: misleading, not for reporting. For S1 bars, compare the full zero baseline with bars starting at 70. The displayed lengths then become 8 and 12 instead of 78 and 82.

In two sentences explain that the shortened bars make the second length look 50 percent larger, while the actual means differ by about 5.1 percent relative to 78. Preserve all numeric labels and explain the deception. Do not submit the counterexample as the honest graph. Use the same values and an equivalent stated distortion for your actual data.

P1: actual data, absence and official requirements

The full task uses your actual physiology data and collection record. Keep the dataset in its approved location and carry forward the March 10 privacy safeguard. Name only non-identifying process details here. Do not assume that the privacy CER or prior table was submitted.

If data are unavailable, label S1 as recovery and request the data needed for the actual-data graph and note. The absence route requires a spreadsheet comparison graph from two columns, correct labels and a two-line bias/error note, followed by upload. S1 can support clearly labeled software practice but cannot certify the actual-data requirement.

Your teacher may assign Activity 2.1.3 Making Results Meaningful. Obtain its graph-format instructions and assigned stopping point from the teacher or myPLTW. Do not mark the official tracker complete merely because this original graph is finished.

No homework is due before this class. The next date is March 12. Weekly requirements still include a physiology data table, graphing, mean, standard deviation, error and the Problem 2 benchmark. The weekly absence route needs the assigned biometric dataset, not invented observations.

The unit later includes bias/error analysis, labeled graph, a statistically justified comparison, data-based CER and a limitation addressing replication. This draft graph does not complete those additional tasks or prove statistical significance. Retain the actual teacher packet, dataset, spreadsheet and official work as separate dependencies.

Restart with the first unfinished item: bias/error list, graph choice, labeled draft, attached note, then confirmed submission. End by naming the possible bias most relevant to your conclusion and why.

M1: a different worked graph decision

For the invented container means in V1, I choose horizontal bars because A and B are separate containers. I start at zero so lengths represent the values fairly. I retain the stated values and do not infer a time trend.

Possible concern: if a thermometer were offset equally for both containers, both means could shift without changing their difference. I would check the measurement record rather than subtract an invented correction. This is reasoning about a fictional possibility, not an actual device failure.

V2 instead connects one sample's values in time order. It answers a different question. Transfer the method: name the comparison, choose the matching display, label values and units, then attach a process-specific limit. Neither model proves a physiological effect.

Try the decision

Which decision fits the S1 comparison and the supplied limits?

- Match the display to the S1 question, retain raw values and explain the process limits the collection record supports.
- Start the bars at 70 and describe the 50 percent difference in drawn lengths as the percent change in pulse-rate means.
- Connect each A row to its B row and claim that each participant increased by 4 bpm.

Explain your choice using the reading. Discuss it or say it to yourself. This practice does not add another submission.

Your 80-minute flow

0–10 minutes	Inspect V1/V2, define bias/error and answer both warmups.
10–30 minutes	Use E1 and actual records or S1 to list possible bias and error.
30–50 minutes	Use E2/R1/M1 to justify a graph type and axes.
50–65 minutes	Draft the labeled graph and check values against the table.
65–77 minutes	Attach the note; save and submit through the confirmed route.
77–80 minutes	Name the most relevant possible bias and explain why.

Your response record

Use these labels on paper or in your document. The space below also works when this page is printed.

Two graph inputs and both warmups

Inspect V1-bar and V2-line and explain each graph's claim. Answer the zero-baseline warmup and name a possible order effect.

G1 supplies full text equivalents. Missing rendered graphs remain a visual-input hold, not proof that you inspected them.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

Study-specific bias and error

Identify your actual study or labeled S1 recovery. List one possible bias and one measurement-error source, and explain how each could affect interpretation.

Use E1 and the collection description. They can overlap. Do not invent the actual direction, size or presence of an error.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

Choose and justify the graph

Choose among bar, line, scatter or box plot for the actual structure and question; a raw-value dot display is also acceptable. State axes, units, pairing status and baseline.

Use E2/R1. For S1 mean bars, keep the raw table with the summary; use supplied summaries if choosing a box plot.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

Labeled graph draft

Draw or build the graph with title, axes, units and all needed values. Label S1 recovery if used. Retain the raw table and graph-choice reason in the same record.

R1 supplies complete S1 plotting instructions. The absence branch still requires spreadsheet creation and upload; paper practice does not complete that branch.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



Bias-and-error annotation and exit

Attach the two-line bias/error note, then name the possible bias most likely to affect your conclusion and why. Check the rest/after-exercise mean-graph example and record missing requirements.

Use C1 and P1. Optional extension adds one labeled misleading comparison and exactly two explanatory sentences; the honest graph remains the submitted draft.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

Check your product

- The graph fits the actual question and record structure, or is explicitly labeled S1 practice.
- Axes, units, title and baseline are readable; plotted values match the source table.
- A specific bias and measurement-error note explains possible effects without inventing causes.
- Raw values remain available when means alone would hide spread.
- Spreadsheet, actual-data, upload and official requirements are tracked honestly.

Keep the limit: Original graphing practice and supplied invented values. No measured student data, physiological effect, device fault, significance, privacy permission or official completion is established. It cannot support conclusions beyond these stated limits.

Turn in your work

Submit the draft graph with its labeled axes, units, title and annotated bias-and-error note through the linked BI assignment. Keep graph choice and raw table with it. The absence route requires a spreadsheet graph and upload. After uploading, check that Schoology shows Submitted.

Save the same work when access is missing. Identify what you need separately for the spreadsheet/upload, actual-data and official requirements. A paper or S1 recovery graph does not establish those branches as complete.

[Open this assignment in Schoology.](#)

Carry forward

Match the graph to the question, show its scale, and explain what the measurement process cannot establish.

Keep the graph and bias-and-error note for the next analysis task. Actual data, privacy and official requirements remain separate. Which feature of your graph could reflect bias rather than a physiological difference?

Sources and resources

[Open today's page](#)

NIST-BIAS · Analysis of bias

NIST/SEMATECH measurement handbook

<https://www.itl.nist.gov/div898/handbook/mpc/section4/mpc45.htm>

NIST-ERROR · Type A evaluations of random components

NIST/SEMATECH measurement handbook

<https://www.itl.nist.gov/div898/handbook/mpc/section5/mpc531.htm>

ONS · Chart details: Axes and gridlines

Office for National Statistics

<https://service-manual.ons.gov.uk/data-visualisation/guidance/axes-and-gridlines>

NIST-SCATTER · Scatter Plot

NIST/SEMATECH engineering statistics handbook

<https://www.itl.nist.gov/div898/handbook/eda/section3/scatterp.htm>

NIST-BOX · Box Plot

NIST/SEMATECH engineering statistics handbook

<https://www.itl.nist.gov/div898/handbook/eda/section3/boxplot.htm>