Layers & Aesthetics

PSY 410: Data Science for Psychology

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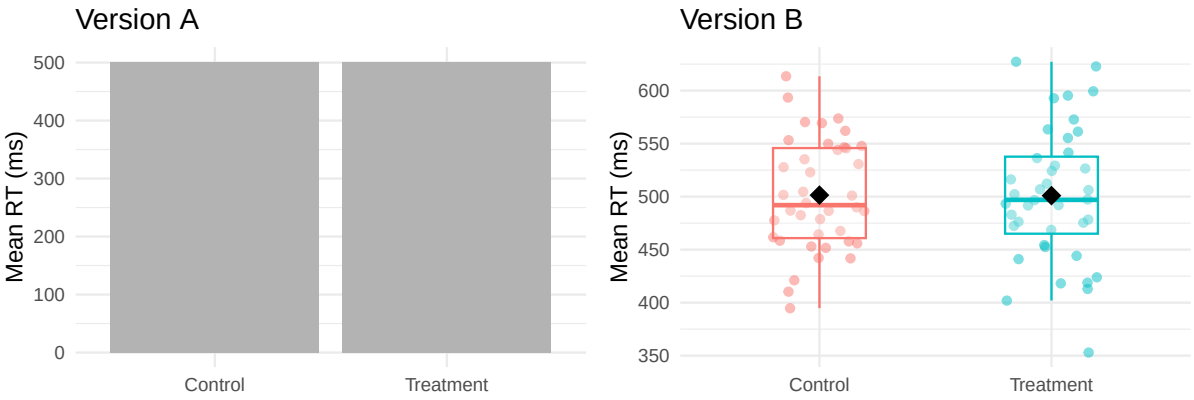
Choosing the right geom

Same data, two stories



Both use the same data. The difference is **layers** — and the right layers tell the right story.

The wrong geom doesn't just look bad — it can actively mislead.

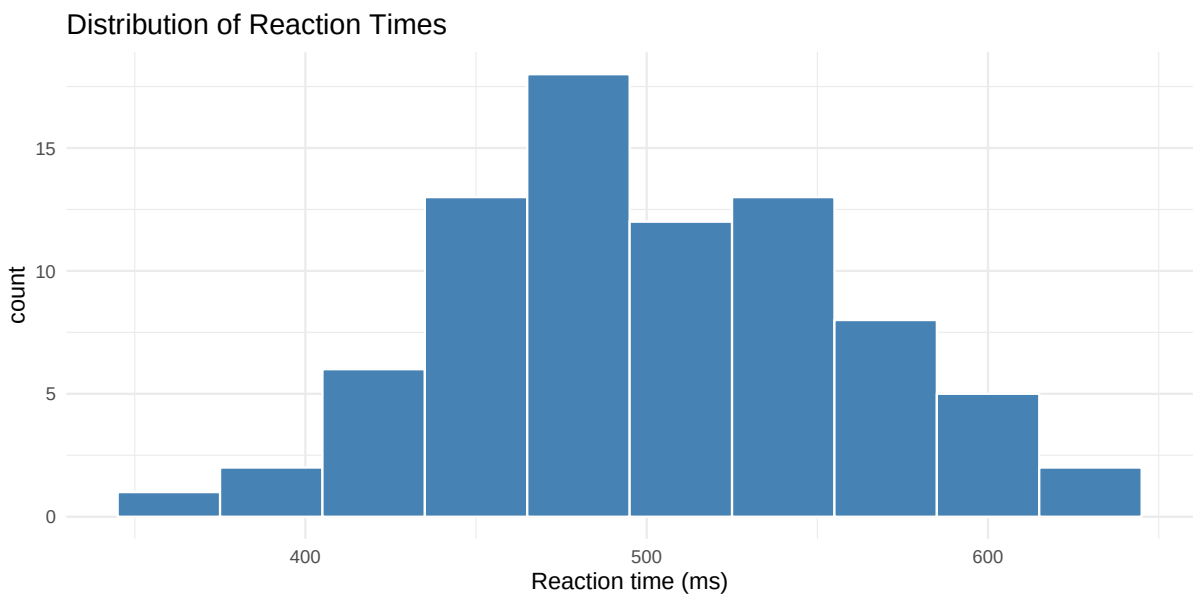
Geom selection guide

Your data	Good geom	Avoid
One continuous variable	`geom_histogram()`, `geom_density()`	`geom_bar()`
One categorical variable	`geom_bar()`	`geom_histogram()`
Two continuous	`geom_point()`, `geom_smooth()`	—

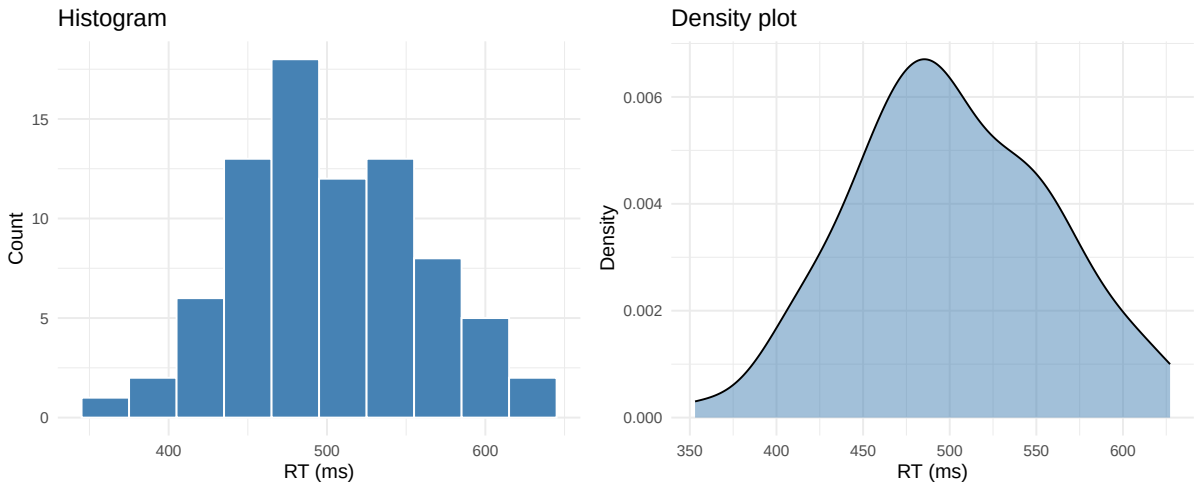
Your data	Good geom	Avoid
One continuous + one categorical	`geom_boxplot()`, `geom_violin()`	pie charts
Two categorical	`geom_count()`, `geom_tile()`	—
Change over time	`geom_line()`	`geom_point()` alone

One variable: distributions

```
reaction_data |>
  ggplot(aes(x = rt)) +
  geom_histogram(
    binwidth = 30,
    fill = "steelblue",
    color = "white") +
  labs(
    title = "Distribution of Reaction Times",
    x = "Reaction time (ms)"
  ) +
  theme_minimal(base_size = 14)
```



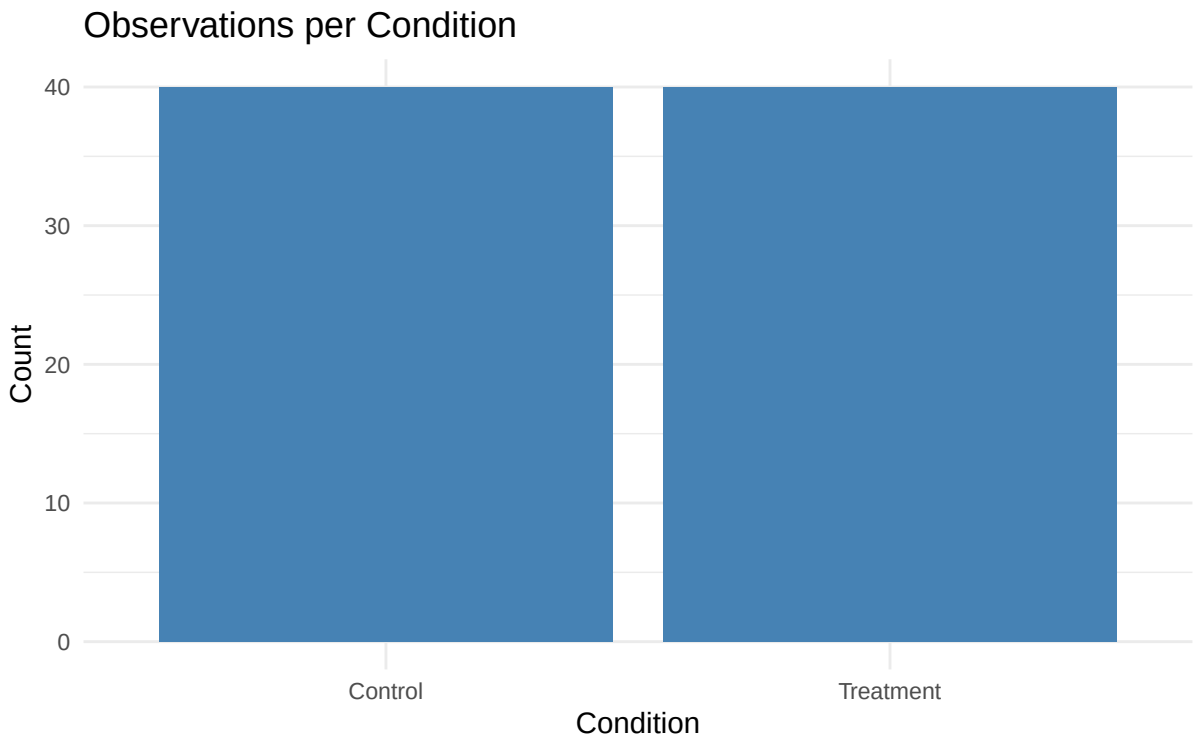
histogram vs density



Histogram = actual counts. Density = smoothed estimate of the shape.

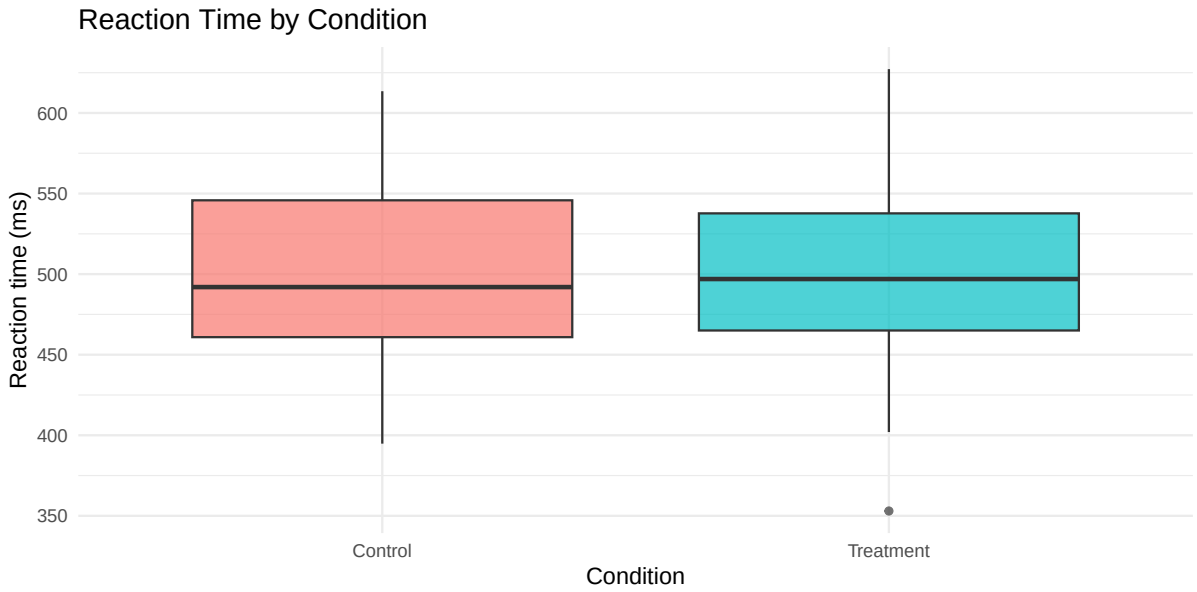
One categorical variable

```
reaction_data |>
  ggplot(aes(x = condition)) +
  geom_bar(fill = "steelblue") +
  labs(
    title = "Observations per Condition",
    x = "Condition",
    y = "Count"
  ) +
  theme_minimal(base_size = 14)
```

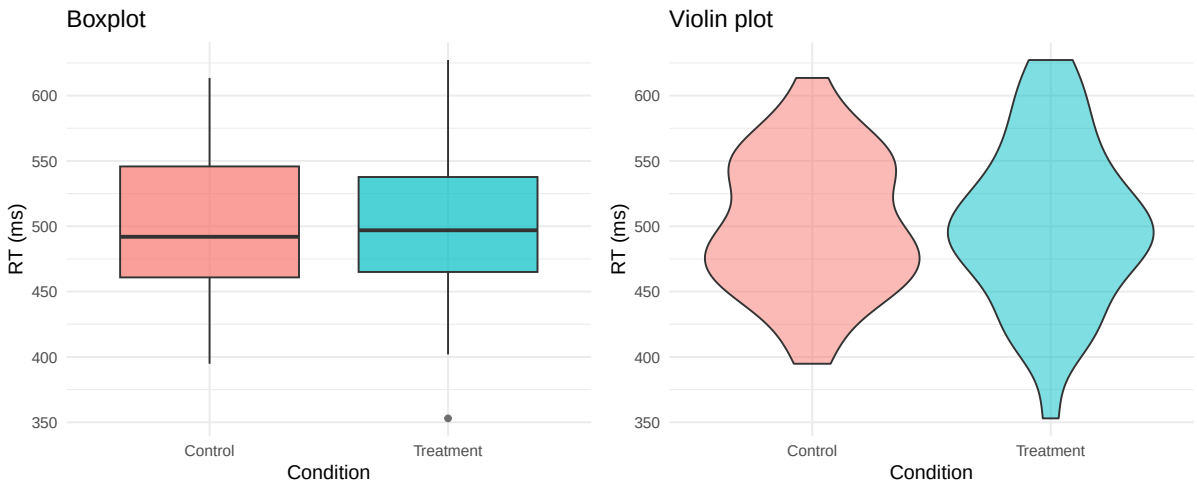


One continuous + one categorical

```
reaction_data |>
  ggplot(aes(x = condition, y = rt, fill = condition)) +
  geom_boxplot(alpha = 0.7) +
  labs(
    title = "Reaction Time by Condition",
    x = "Condition",
    y = "Reaction time (ms)"
  ) +
  theme_minimal(base_size = 14) +
  theme(legend.position = "none")
```



boxplot vs violin



Violin shows the full distribution shape. Boxplot shows summary stats. Both have their place.

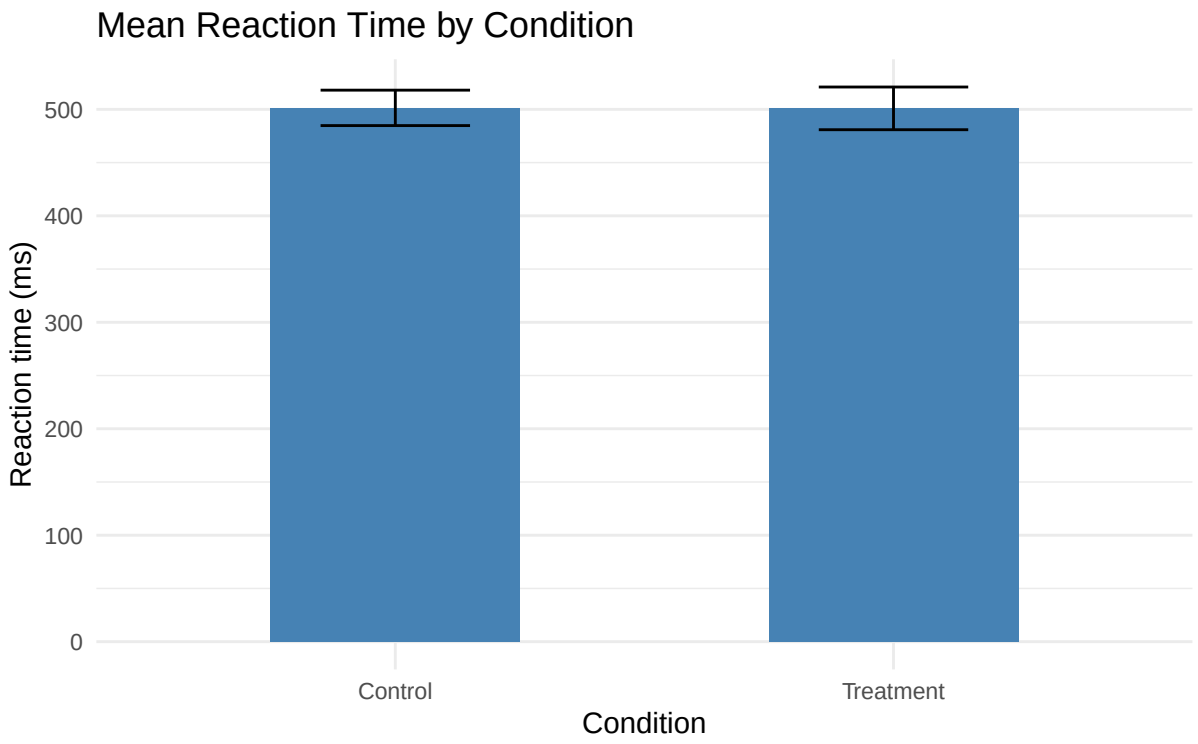
stat_summary()

The psychology staple: means + error bars

In psych papers, you'll see this constantly: a bar chart showing group means with error bars. `stat_summary()` is how you make it.

stat_summary() basics

```
reaction_data |>
  ggplot(aes(x = condition, y = rt)) +
  stat_summary(
    fun = mean,
    geom = "bar",
    fill = "steelblue", width = 0.5) +
  stat_summary(
    fun.data = mean_cl_normal,
    geom = "errorbar",
    width = 0.3) +
  labs(
    title = "Mean Reaction Time by Condition",
    x = "Condition",
    y = "Reaction time (ms)"
  ) +
  theme_minimal(base_size = 14)
```



Breaking down stat_summary()

```
# The bar (mean)
stat_summary(fun = mean, geom = "bar")

# The error bars (95% confidence interval)
stat_summary(fun.data = mean_cl_normal, geom = "errorbar")
```

- `fun` = the function to calculate (mean, median, etc.)
- `fun.data` = a function that returns ymin, y, ymax (like `mean_cl_normal`)
- `geom` = what shape to use to show the result

What are error bars showing?

This matters! Always state it in your figure caption.

Error bar type	What it means	How to get it
SE (standard error)	Precision of the mean	`mean_se`

Error bar type	What it means	How to get it
SD (standard deviation)	Spread of the data	Write your own
95% CI	Confidence interval	`mean_cl_normal`

```
# SE
stat_summary(fun.data = mean_se, geom = "errorbar")

# 95% CI (most common in psych)
stat_summary(fun.data = mean_cl_normal, geom = "errorbar")
```

Why does this matter?

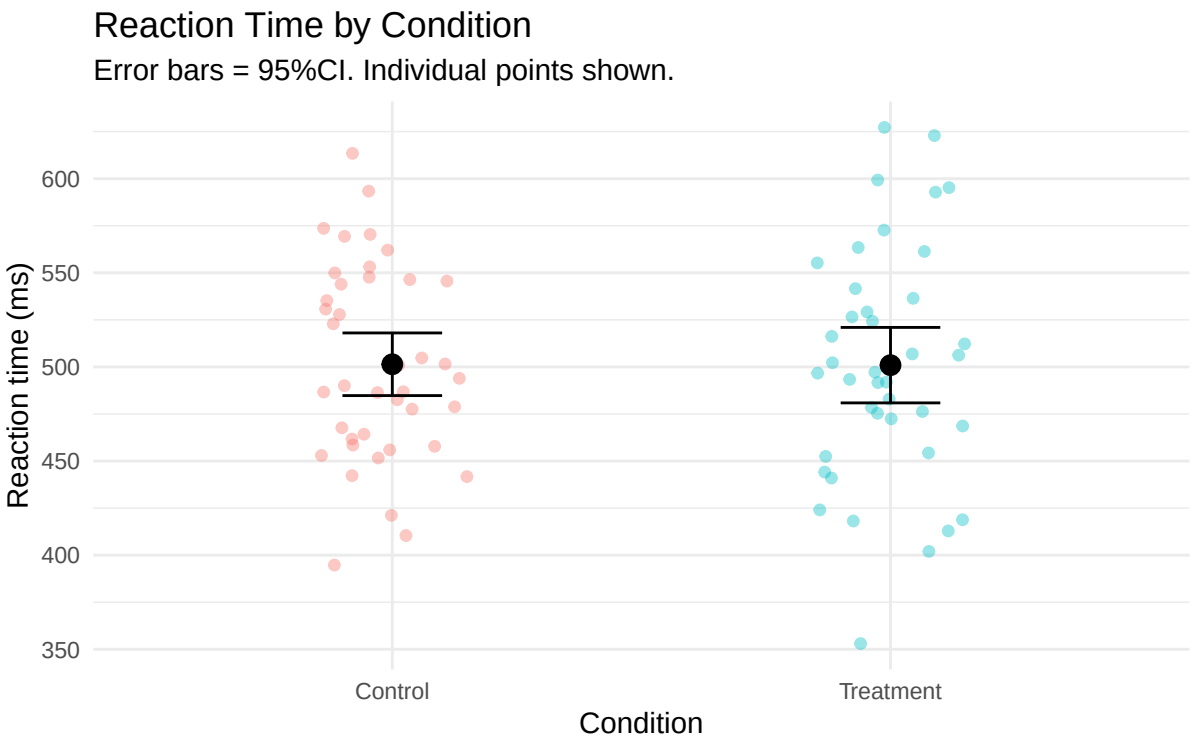
The APA Publication Manual (7th ed.) recommends showing individual data points alongside summary statistics whenever possible.

Bar charts with error bars are ubiquitous in psychology — but they hide the *shape* of the data. Outliers, bimodality, and floor/ceiling effects all disappear behind a rectangle.

Adding individual data points

Error bars alone hide the data. Show the points too:

```
reaction_data |>
  ggplot(aes(x = condition, y = rt, color = condition)) +
  geom_jitter(width = 0.15, alpha = 0.4, size = 2) +
  stat_summary(fun = mean, geom = "point", size = 4, color = "black") +
  stat_summary(fun.data = mean_cl_normal, geom = "errorbar", width = 0.2, color = "black") +
  labs(
    title = "Reaction Time by Condition",
    subtitle = "Error bars = 95%CI. Individual points shown.",
    x = "Condition",
    y = "Reaction time (ms)"
  ) +
  theme_minimal(base_size = 14) +
  theme(legend.position = "none")
```



Pair coding break

Your turn: 10 minutes

Using the `reaction_data` dataset:

1. Create a **bar chart with error bars** showing mean RT by condition
2. Add **individual data points** (jittered) behind the bars
3. Color the bars by condition
4. Add a caption noting that error bars show the 95% CI.

> Tip
>
> You'll need `stat_summary()` twice — once for the bar, once for the error bars. Look at the examples from the last few slides.

Before we move on

Upload your code to Canvas for participation credit. Paste what you have into today's in-class submission — it doesn't need to work perfectly.

Position & scales

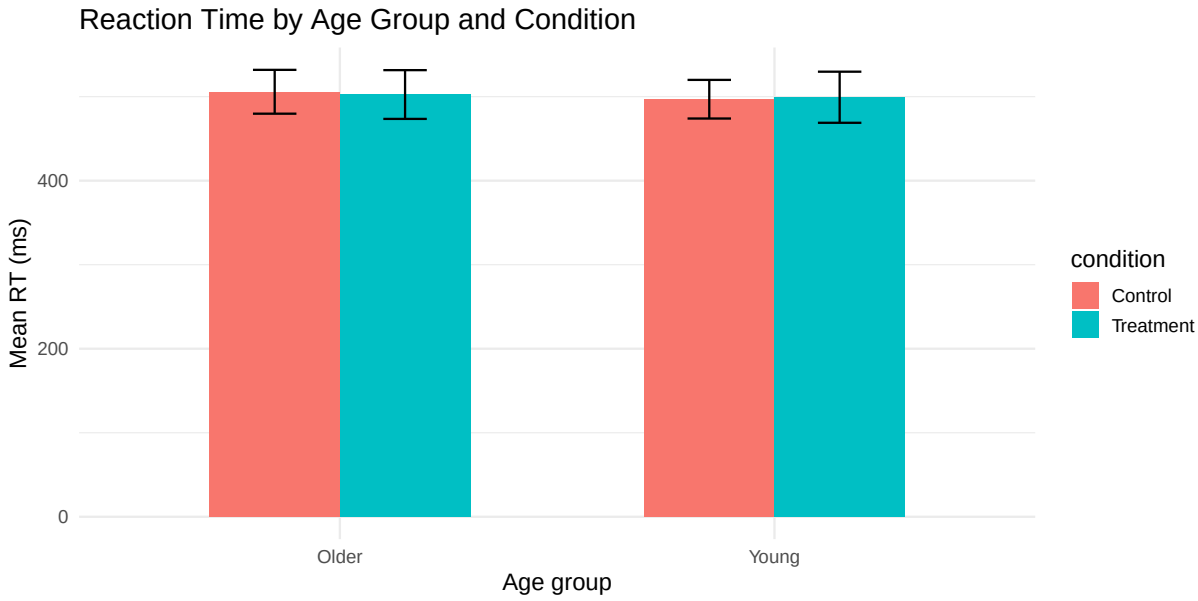
Position adjustments

When geoms overlap, position adjustments fix it:

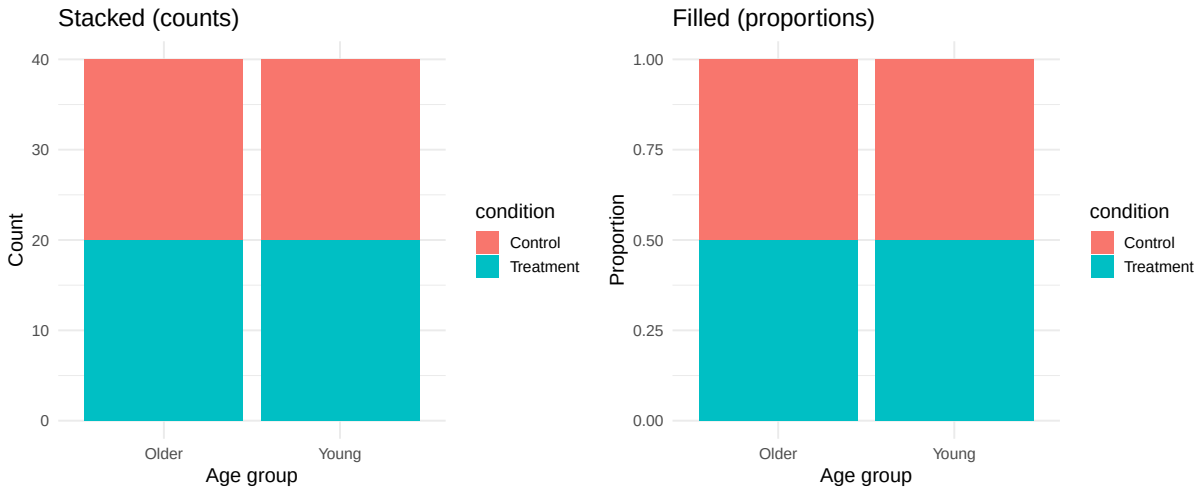
Position	What it does	When to use
`"dodge"`	Side by side	Grouped bar charts
`"stack"`	Stacked on top	Stacked bars
`"fill"`	Stacked to 100%	Comparing proportions
`"jitter"`	Random wiggle	Overplotted points

dodge: grouped bar charts

```
reaction_data |>
  ggplot(aes(x = age_group, y = rt, fill = condition)) +
  stat_summary(fun = mean, geom = "bar", position = "dodge", width = 0.6) +
  stat_summary(fun.data = mean_cl_normal, geom = "errorbar",
               position = position_dodge(0.6), width = 0.2) +
  labs(
    title = "Reaction Time by Age Group and Condition",
    x = "Age group",
    y = "Mean RT (ms)"
  ) +
  theme_minimal(base_size = 14)
```



stack and fill



Scales: controlling axes and colors

Scales translate data values into visual properties:

```
# Control axis range
scale_y_continuous(limits = c(0, 800))
```

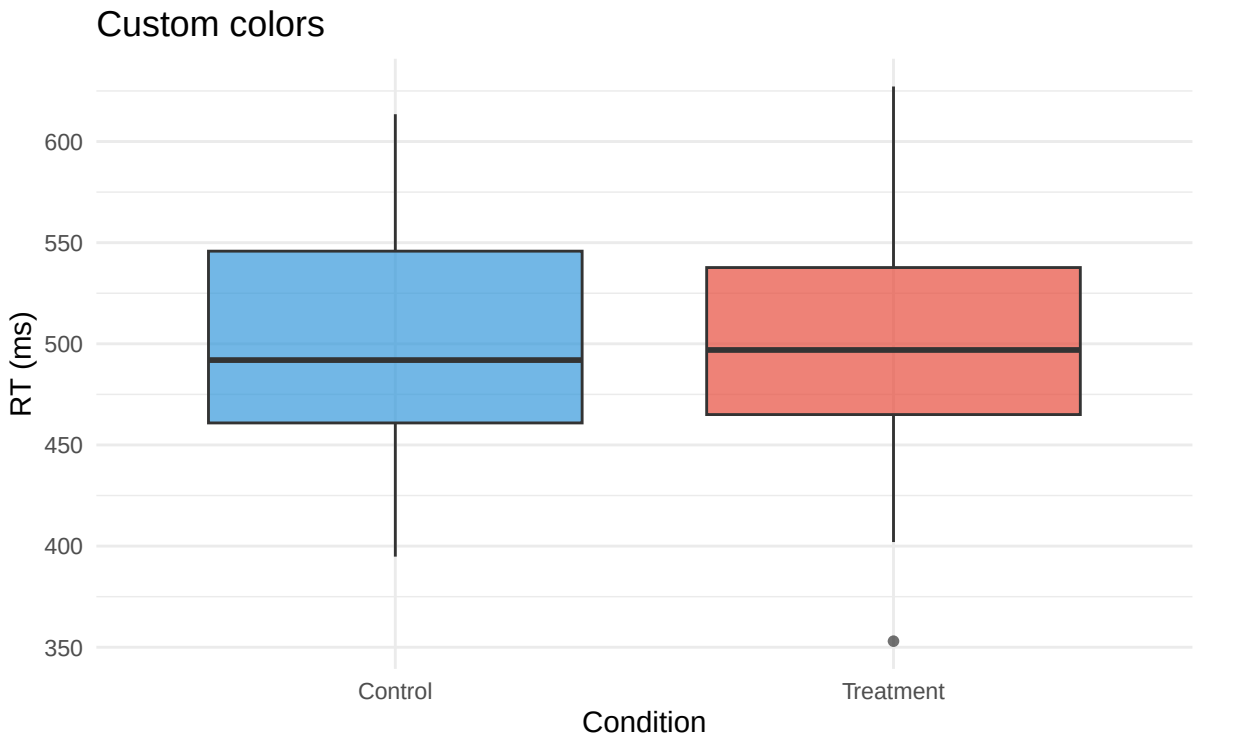
```r
# Control axis breaks (tick marks)
scale_x_continuous(breaks = seq(400, 700, by = 50))

# Set specific colors
scale_fill_manual(values = c("Control" = "lightblue", "Treatment" = "coral"))

# Use a colorblind-friendly palette
scale_fill_viridis_d()
```

scale_fill_manual()

```r
reaction_data |>
  ggplot(aes(x = condition, y = rt, fill = condition)) +
  geom_boxplot(alpha = 0.7) +
  scale_fill_manual(values = c("Control" = "#3498db", "Treatment" = "#e74c3c")) +
  labs(title = "Custom colors", x = "Condition", y = "RT (ms)") +
  theme_minimal(base_size = 14) +
  theme(legend.position = "none")
```



Use a website like HTML color codes to find the appropriate HEX code for your color.

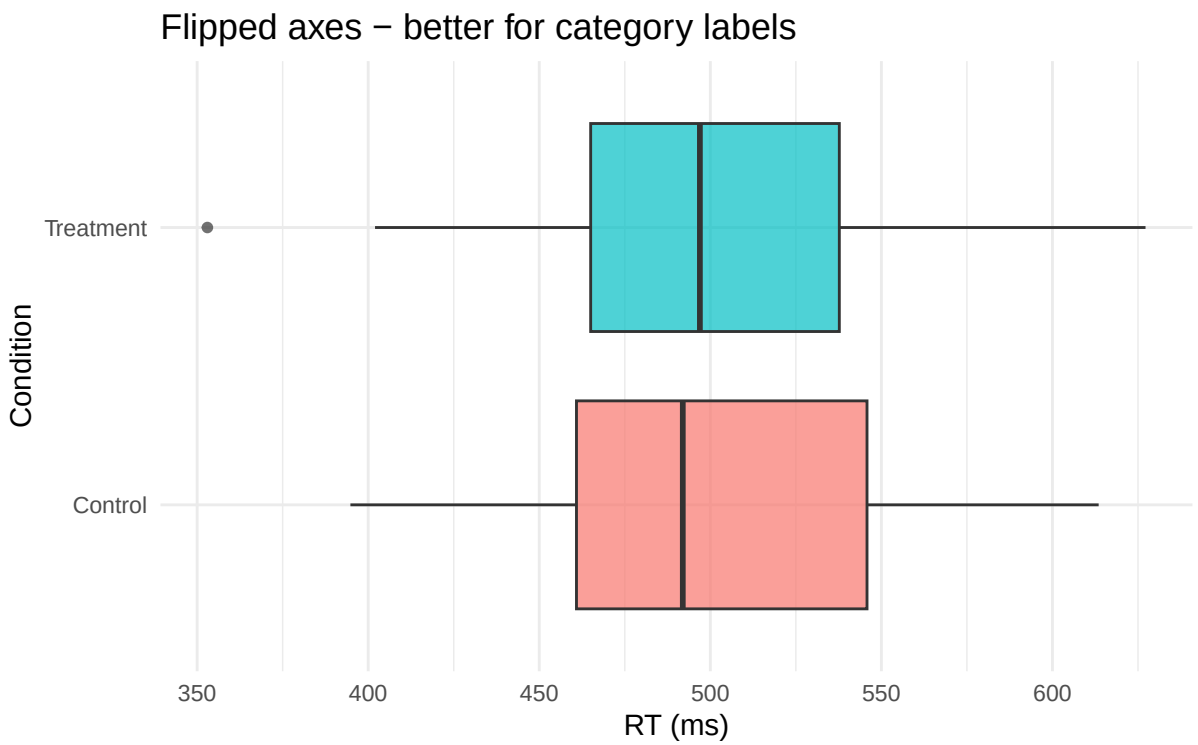
Coordinate systems

```
# Flip x and y (great for long category labels)
coord_flip()

# Zoom in without dropping data
coord_cartesian(ylim = c(400, 600))
# vs
scale_y_continuous(limits = c(400, 600))  # This DROPS data outside the range!
```

coord_flip() in action

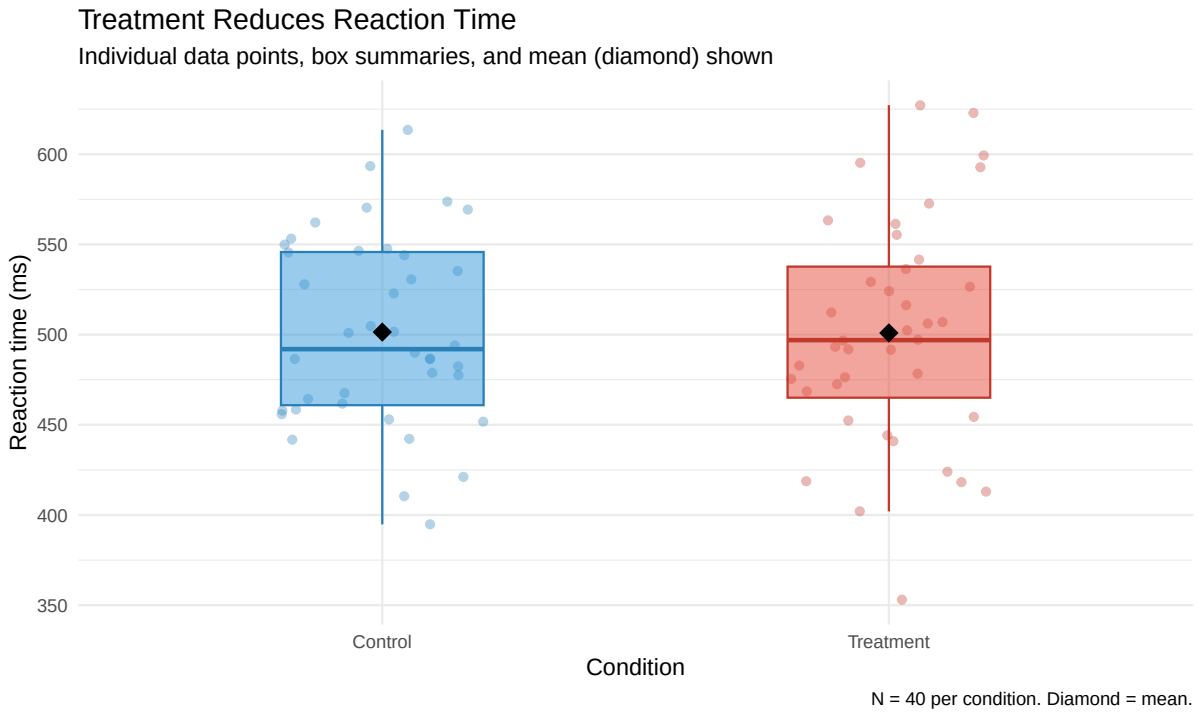
```
reaction_data |>
  ggplot(aes(y = condition, x = rt, fill = condition)) +
  geom_boxplot(alpha = 0.7) +
  labs(title = "Flipped axes - better for category labels", y = "Condition", x = "RT (ms)") +
  theme_minimal(base_size = 14) +
  theme(legend.position = "none")
```



Putting it together

A polished psychology figure

```
reaction_data |>
  ggplot(aes(x = condition, y = rt, fill = condition, color = condition)) +
  geom_jitter(width = 0.2, alpha = 0.35, size = 2) +
  geom_boxplot(alpha = 0.5, width = 0.4, outlier.shape = NA) +
  stat_summary(fun = mean, geom = "point", shape = 18, size = 5, color = "black") +
  scale_fill_manual(values = c("Control" = "#3498db", "Treatment" = "#e74c3c")) +
  scale_color_manual(values = c("Control" = "#2980b9", "Treatment" = "#c0392b")) +
  labs(
    title = "Treatment Reduces Reaction Time",
    subtitle = "Individual data points, box summaries, and mean (diamond) shown",
    x = "Condition",
    y = "Reaction time (ms)",
    caption = "N = 40 per condition. Diamond = mean."
  ) +
  theme_minimal(base_size = 14) +
  theme(legend.position = "none")
```



Get a head start

Assignment 4 preview

Assignment 4 will ask you to create "bad" and "good" versions of figures. Start experimenting:

1. Take any plot from today and make it **deliberately bad** — wrong geom, missing labels, confusing colors
2. Then fix it. What did you change and why?
3. Try creating the same data with three different geoms. Which one communicates best?

Wrapping up

Today's toolkit

Tool	What it does
`geom_histogram()`	Distribution of one continuous variable
`geom_density()`	Smooth distribution estimate
`geom_boxplot()`	Summary of continuous by categorical
`geom_violin()`	Full distribution by categorical
`stat_summary()`	Calculate and display summary stats
`position = "dodge"`	Side-by-side grouped plots
`scale_fill_manual()`	Custom colors
`coord_flip()`	Swap axes

Before next class

Read:

- Supplementary: Visual perception principles (will be posted)
- Optional: Knaflic, *Storytelling with Data*, Ch 1–3

Practice:

- Create a bar chart with error bars for a dataset of your choice
- Try boxplot vs violin on the same data
- Experiment with `coord_flip()` and `scale_fill_manual()`

Key takeaways

1. **Match your geom to your data** — the wrong choice misleads
2. **stat_summary() is powerful** — means, error bars, custom functions
3. **Position adjustments** handle overlap (dodge, stack, fill, jitter)
4. **Scales control** axes, colors, and legends
5. **coord_cartesian() zooms; scale limits drop data** — know the difference

The one thing to remember

The difference between a chart and a figure is intention — every layer should earn its place.

Next time: Perception & Design