Data models, grammar of graphics

SI 649 W20: Information visualization

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University of Michigan
Portions of slides adapted from Eytan Adar

(quiz)

(slack)

Join here: https://tinyurl.com/yaq8luzg

(laptops)

(waitlist)

This week

Lecture

Data types

Grammar of graphics

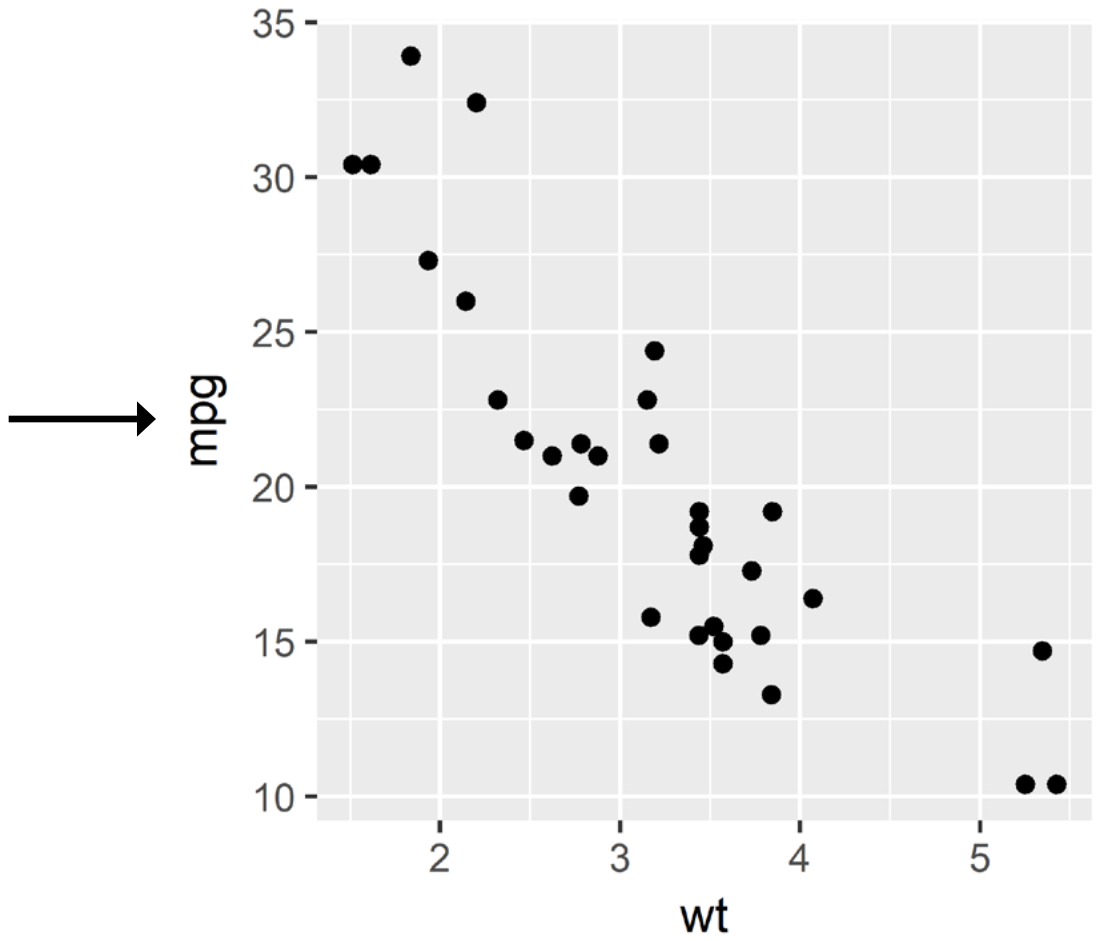
Lab

Altair (based on grammar of graphics)

(individual assignment reminder)

Grammar of graphics...

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am
Mazda RX4	21.0	6	160.0	110	3.90	2.620	16.46	0	1
Mazda RX4 Wag	21.0	6	160.0	110	3.90	2.875	17.02	0	1
Datsun 710	22.8	4	108.0	93	3.85	2.320	18.61	1	1
Hornet 4 Drive	21.4	6	258.0	110	3.08	3.215	19.44	1	0
Hornet Sportabout	18.7	8	360.0	175	3.15	3.440	17.02	0	0
Valiant	18.1	6	225.0	105	2.76	3.460	20.22	1	0
Duster 360	14.3	8	360.0	245	3.21	3.570	15.84	0	0
Merc 240D	24.4	4	146.7	62	3.69	3.190	20.00	1	0
Merc 230	22.8	4	140.8	95	3.92	3.150	22.90	1	0
Merc 280	19.2	6	167.6	123	3.92	3.440	18.30	1	0
Merc 280C	17.8	6	167.6	123	3.92	3.440	18.90	1	0
Merc 450SE	16.4	8	275.8	180	3.07	4.070	17.40	0	0
Merc 450SL	17.3	8	275.8	180	3.07	3.730	17.60	0	0
Merc 450SLC	15.2	8	275.8	180	3.07	3.780	18.00	0	0
Cadillac Fleetwood	10.4	8	472.0	205	2.93	5.250	17.98	0	0
Lincoln Continental	10.4	8	460.0	215	3.00	5.424	17.82	0	0
Chrysler Imperial	14.7	8	440.0	230	3.23	5.345	17.42	0	0
Fiat 128	32.4	4	78.7	66	4.08	2.200	19.47	1	1
Honda Civic	30.4	4	75.7	52	4.93	1.615	18.52	1	1
Toyota Corolla	33.9	4	71.1	65	4.22	1.835	19.90	1	1
Toyota Corona	21.5	4	120.1	97	3.70	2.465	20.01	1	0
Dodge Challenger	15.5	8	318.0	150	2.76	3.520	16.87	0	0
AMC Javelin	15.2	8	304.0	150	3.15	3.435	17.30	0	0
Camaro Z28	13.3	8	350.0	245	3.73	3.840	15.41	0	0
Pontiac Firebird	19.2	8	400.0	175	3.08	3.845	17.05	0	0
Fiat X1-9	27.3	4	79.0	66	4.08	1.935	18.90	1	1



Let's systematize "turning data into a vis"

data -> ??? -> marks on the screen (or paper)

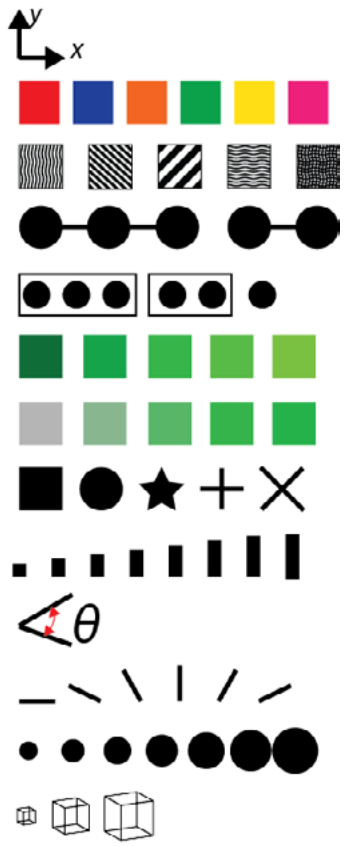
??? = ~~New function for every chart type~~
= ~~Low-level drawing functions~~
= Grammar of graphics

Encode data with visual channels
Display encodings with marks

Channels / encodings -> Marks

("aesthetics" in ggplot)

Position
Color Hue
Texture
Connection
Containment
Density
Color Saturation
Shape
Length
Angle
Slope
Area
Volume



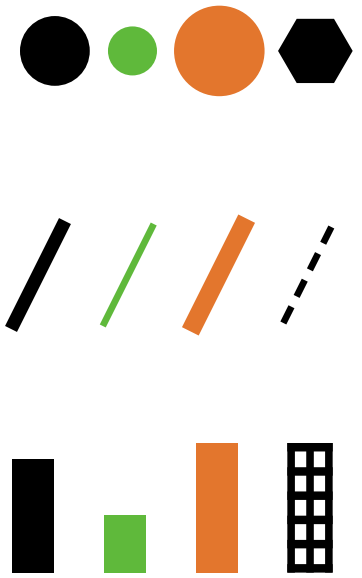
("geometries" in ggplot)

Points

Lines

Bars

etc



Grammar of graphics

Codifies data types, encodings/channels, marks

Maps data -> channels -> marks

Data types

Basic data types — A simple taxonomy

Categorical (aka Nominal)

Ordinal

Quantitative

Group activity

In groups, agree on answers to the quiz

Basic data types — A simple taxonomy

Categorical

Ordinal

Quantitative

- sometimes subdivided: interval versus ratio

Basic data types — Operations

Categorical: $= \neq$

Ordinal: $= \neq < >$

Quantitative: $= \neq < > + - (\times \div)$

Quantitative -> Ordinal -> Categorical

Quantitative temperature °F
-50
30
300
-10
70
-250
2000

Quantitative -> Ordinal -> Categorical

Quantitative temperature °F	**Ordinal** cold < warm < hot
-50	cold
30	cold
300	hot
-10	cold
70	warm
-250	cold
2000	hot

Quantitative -> Ordinal -> Categorical

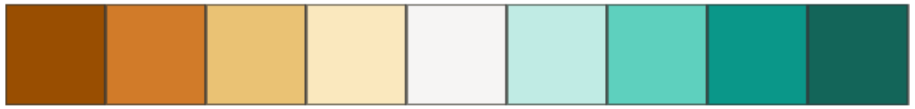
Quantitative temperature °F	**Ordinal** cold < warm < hot	**Categorical** burned ≠ not burned
-50	cold	not burned
30	cold	not burned
300	hot	burned
-10	cold	not burned
70	warm	not burned
-250	cold	not burned
2000	hot	burned

Sequential / diverging scales

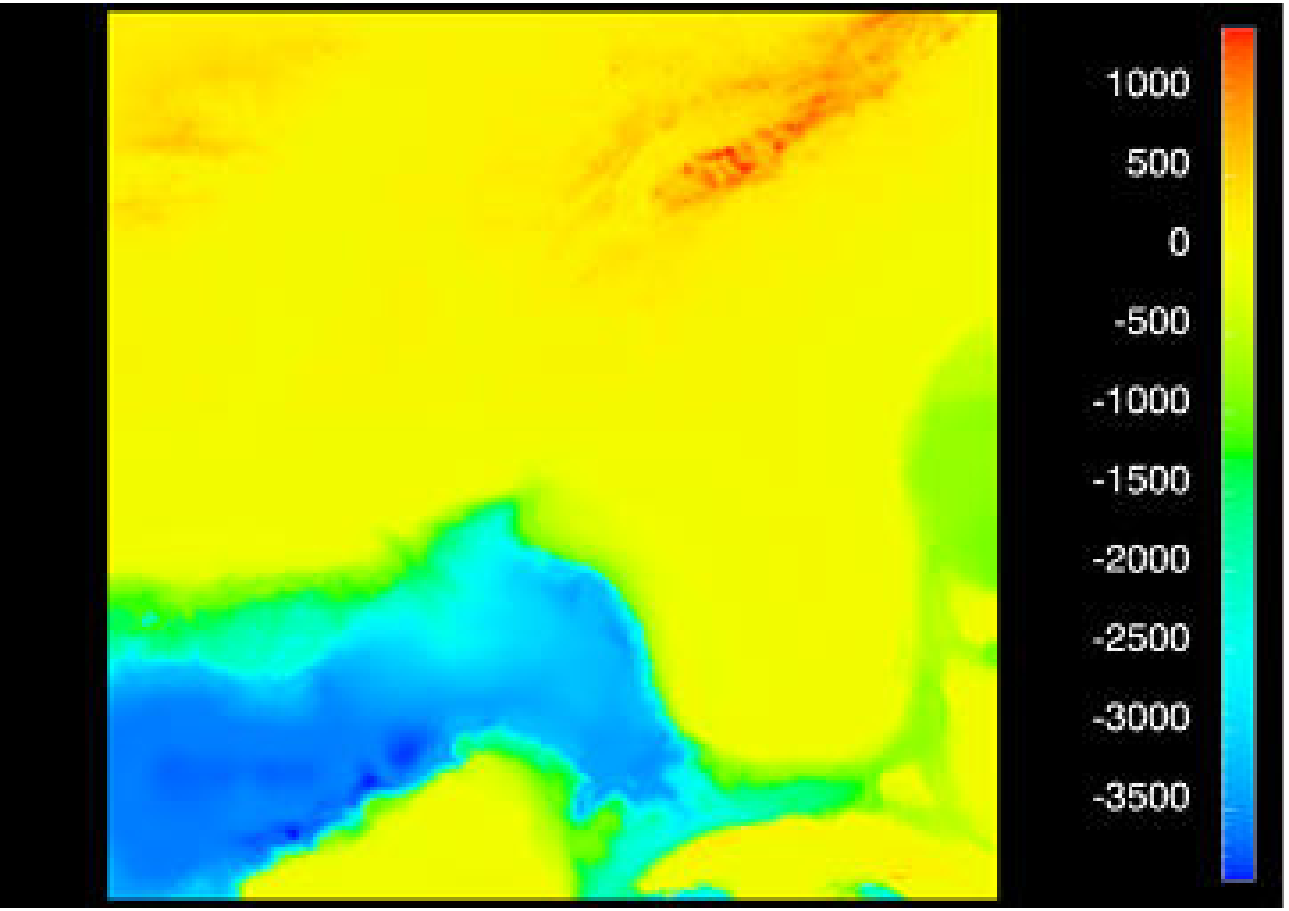
Ordinal / quantitative data may
also be sequential or diverging

This impacts encoding choice, for example:

Sequential color scale: 

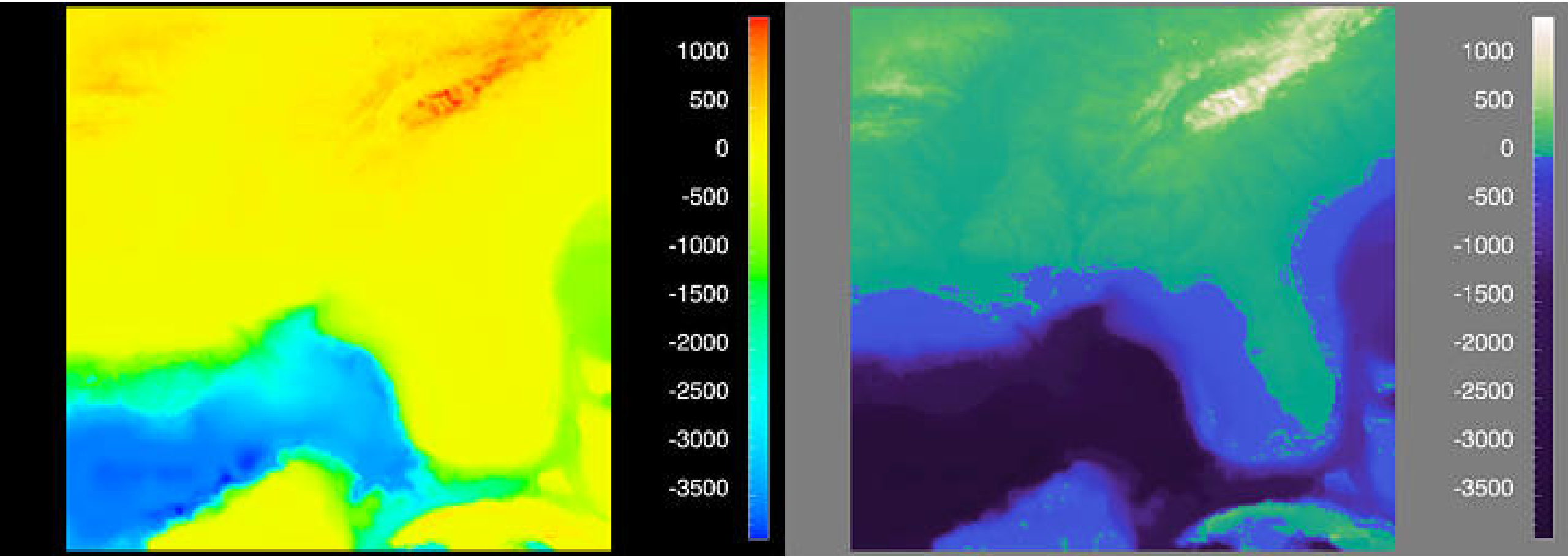
Diverging color scale: 

Sequential / diverging scales



[http://www.research.ibm.com/people/l/lloydt/color/color.HTM]

Sequential / diverging scales



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Okay, back to grammar of graphics...

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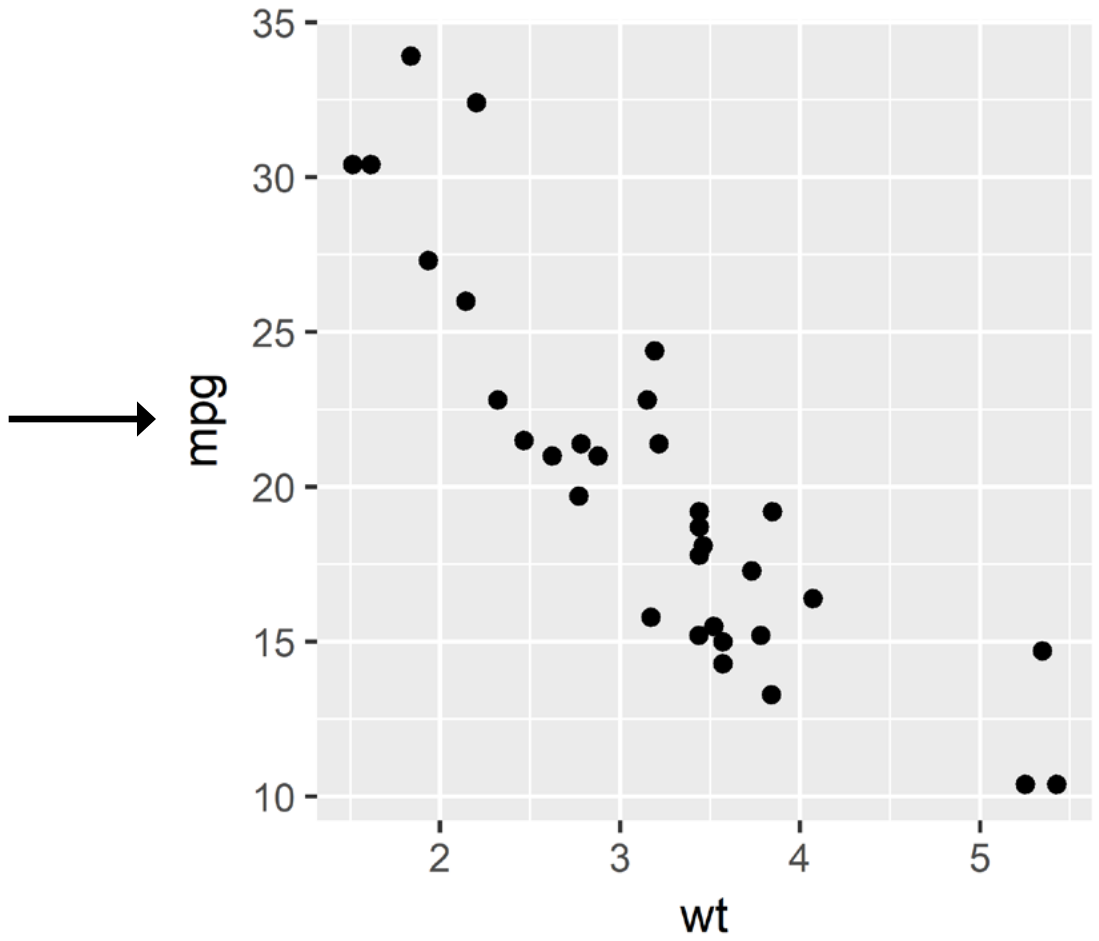
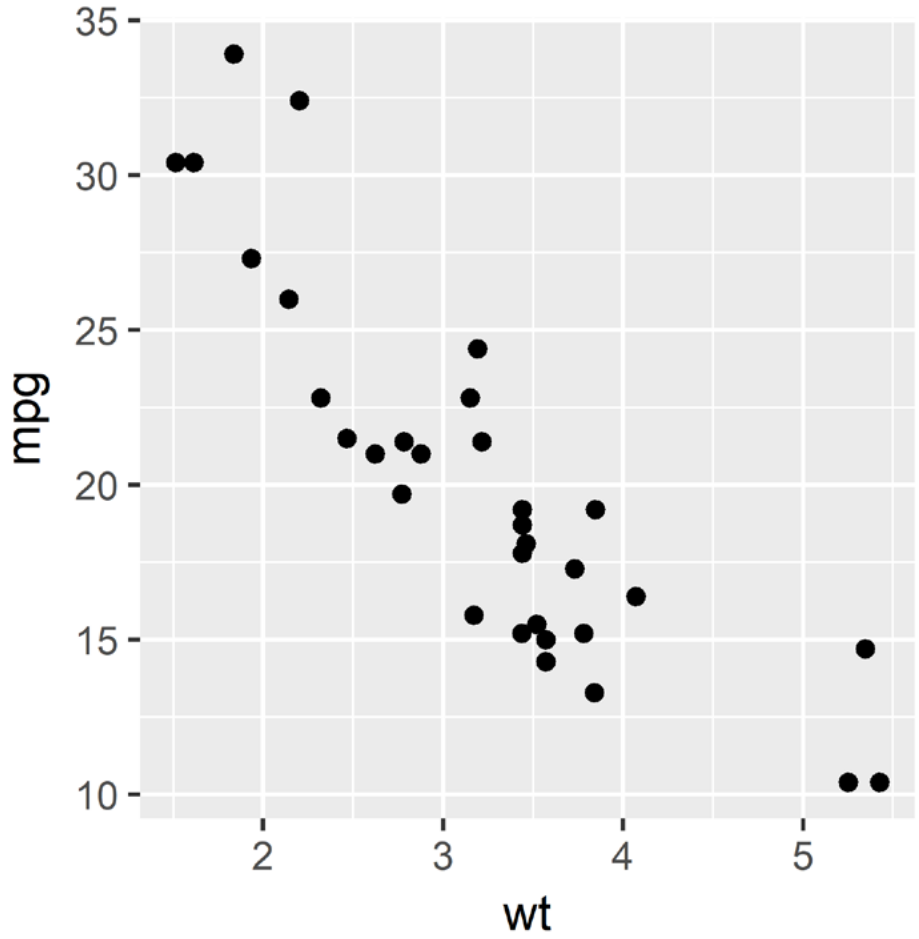


Grammar of graphics

mpg: numeric
wt: numeric

wt -> x position
mpg -> y position

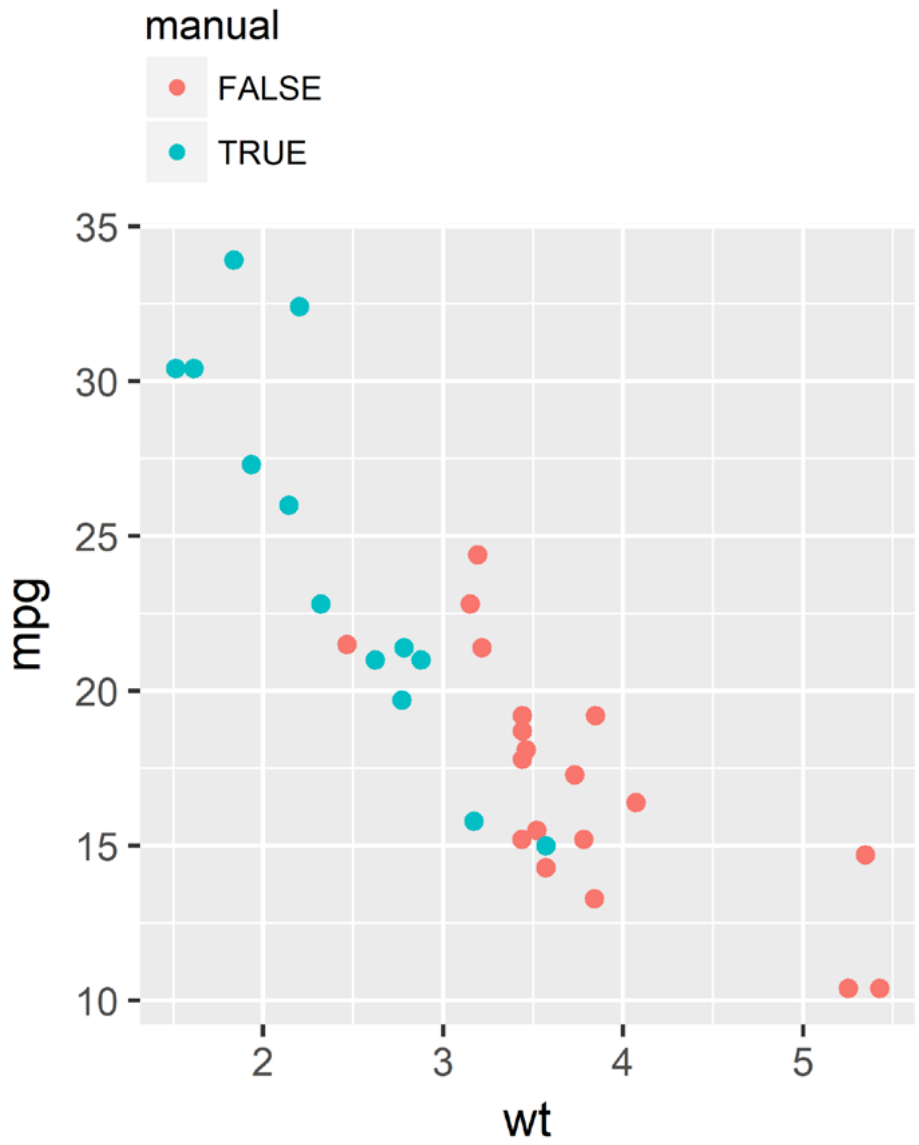
mark: point



Grammar of graphics

mpg: numeric
wt: numeric
→manual: nominal
wt -> x position
mpg -> y position
→manual -> color

mark: point



Grammar of graphics

mpg: numeric
wt: numeric
manual: nominal
wt -> x position
mpg -> y position
manual -> color
manual -> shape ←
mark: point

Why is the grammar of graphics useful?

1. Easier to specify many charts, combinations

2. Helps you evaluate charts systematically

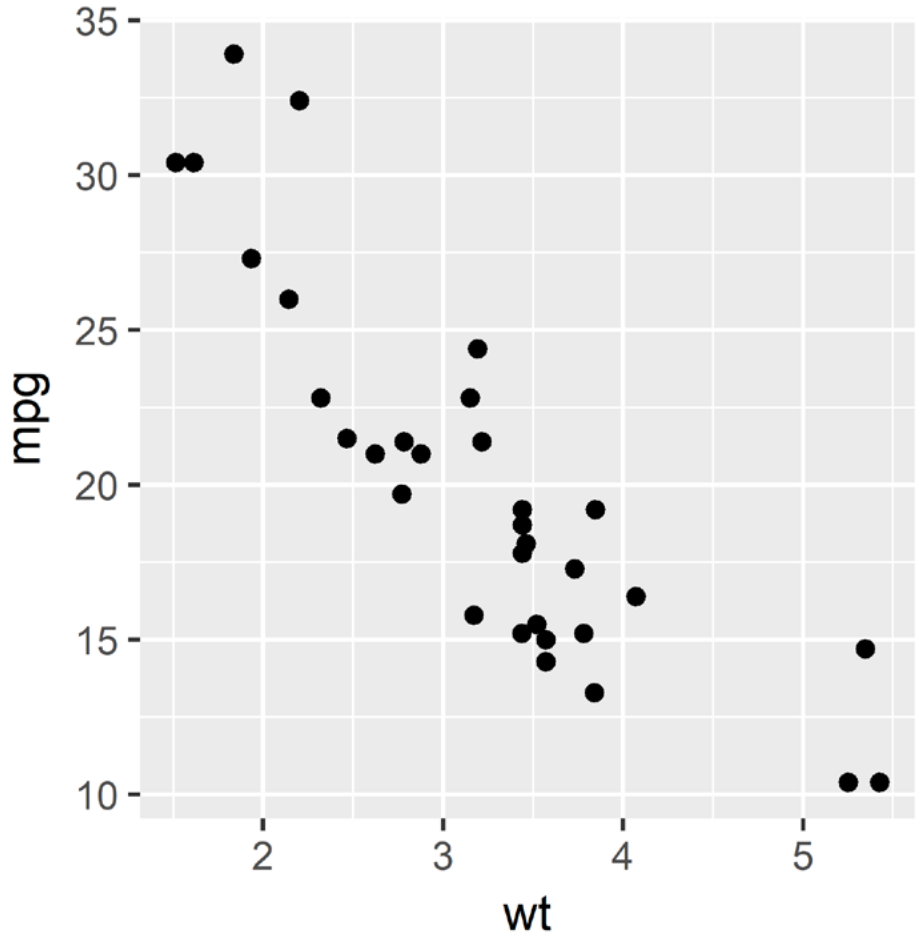
3. Helps you design charts systematically

1. Easier to specify many charts, combinations

mpg: numeric
wt: numeric

wt -> x position
mpg -> y position

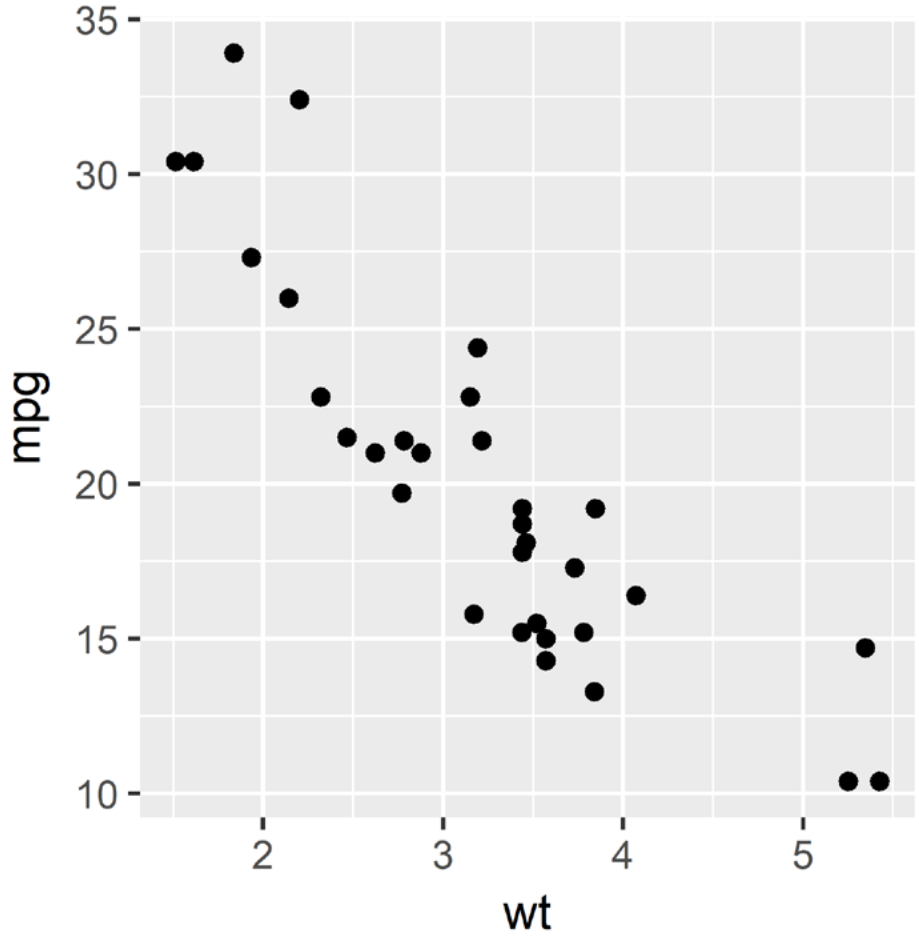
mark: point



1. Easier to specify many charts, combinations

Not:

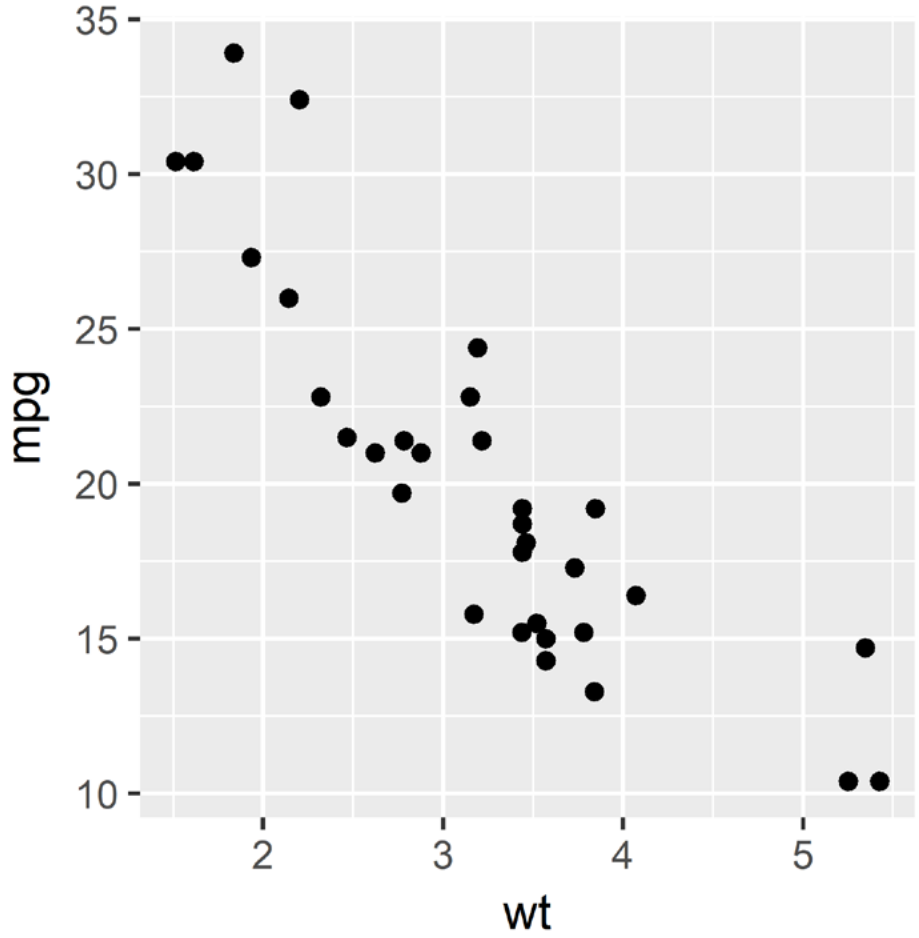
```
some_big_function_to_make_scatterplots(
    my_data,
    a_bunch_of_options
)
```



1. Easier to specify many charts, combinations

Not:

```
some_function_to_draw_grid()
some_function_to_draw_axes()
for (row in data) {
   draw_point(data[i]["x"], ...)
}
 ...
```

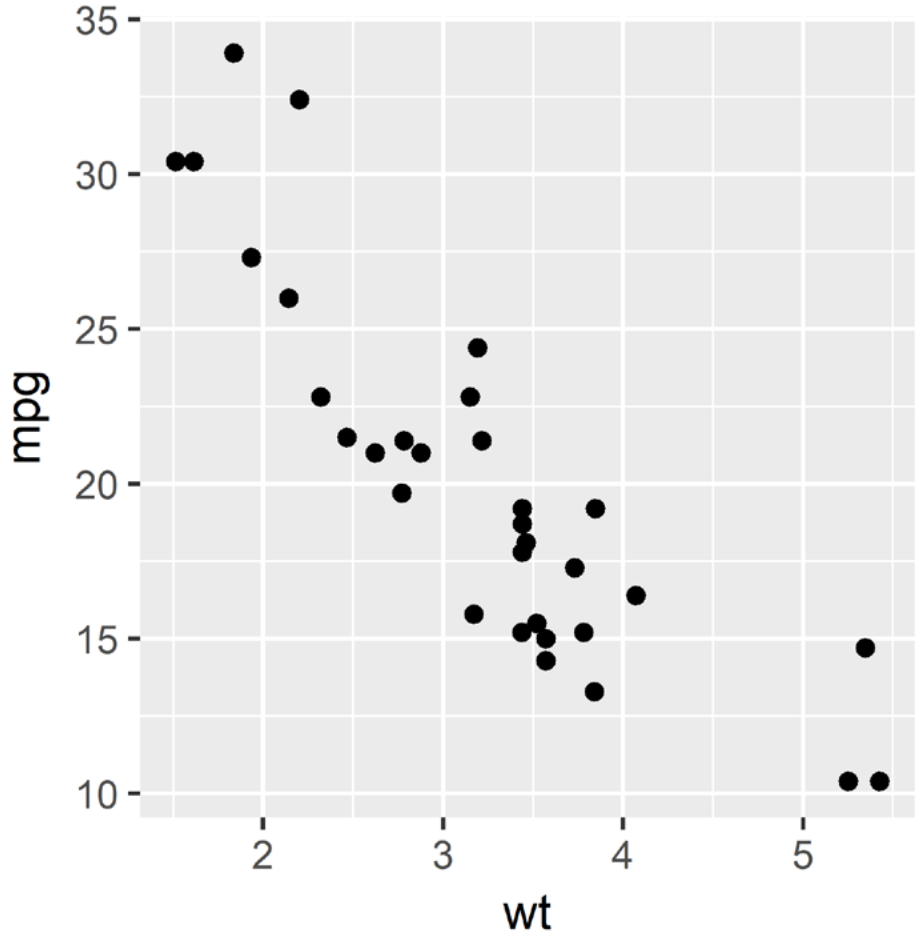


1. Easier to specify many charts, combinations

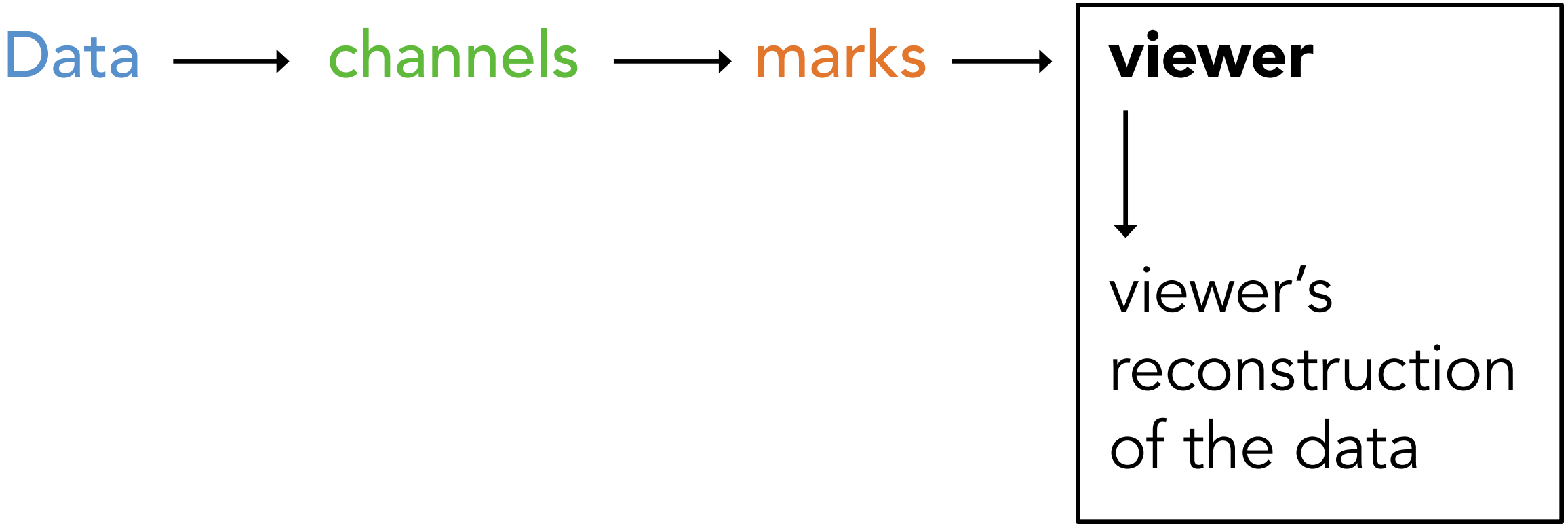
e.g., in Altair:

(data, channels, marks)

```
alt.Chart(mtcars)\
    .encode(
        x = 'wt',
        y = 'mpg'
    )\
    .mark_point()
```



2. Helps you evaluate charts systematically



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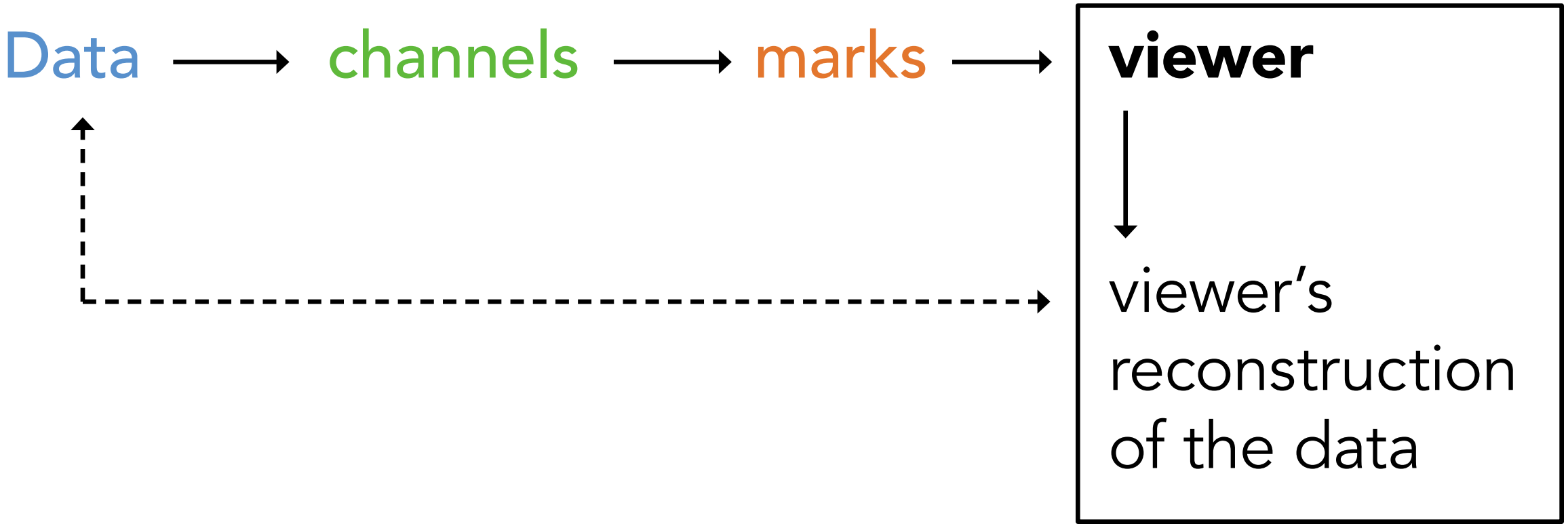
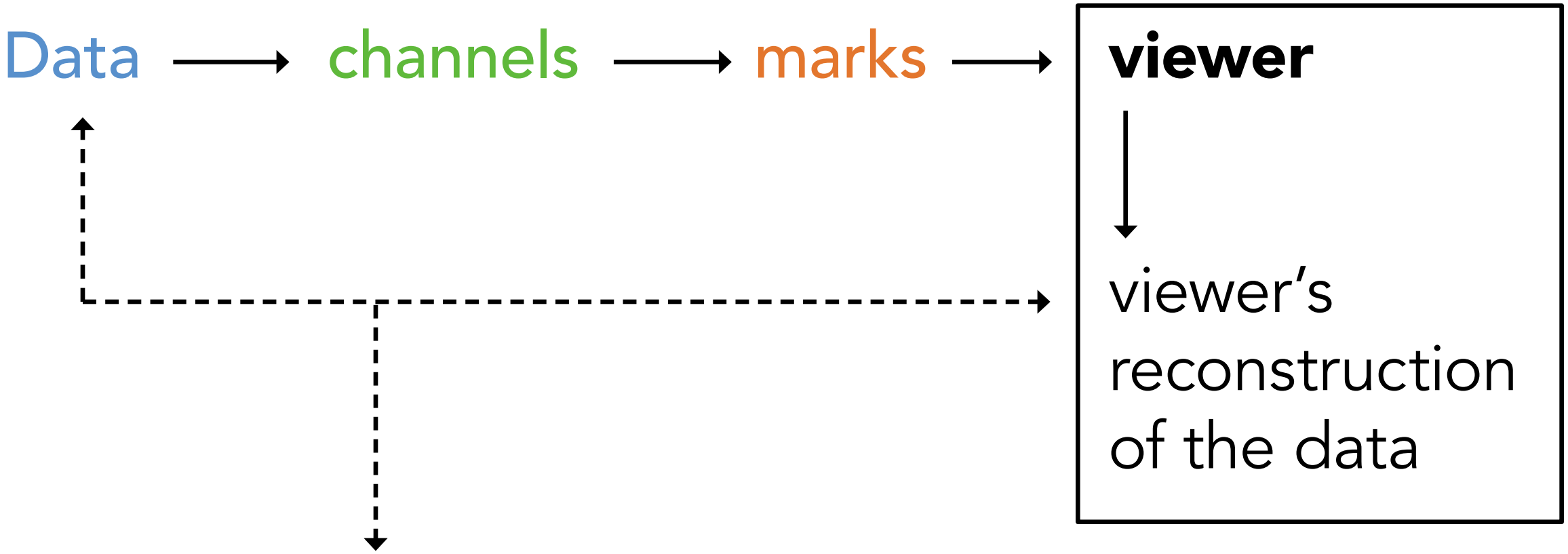


2. Helps you evaluate charts systematically



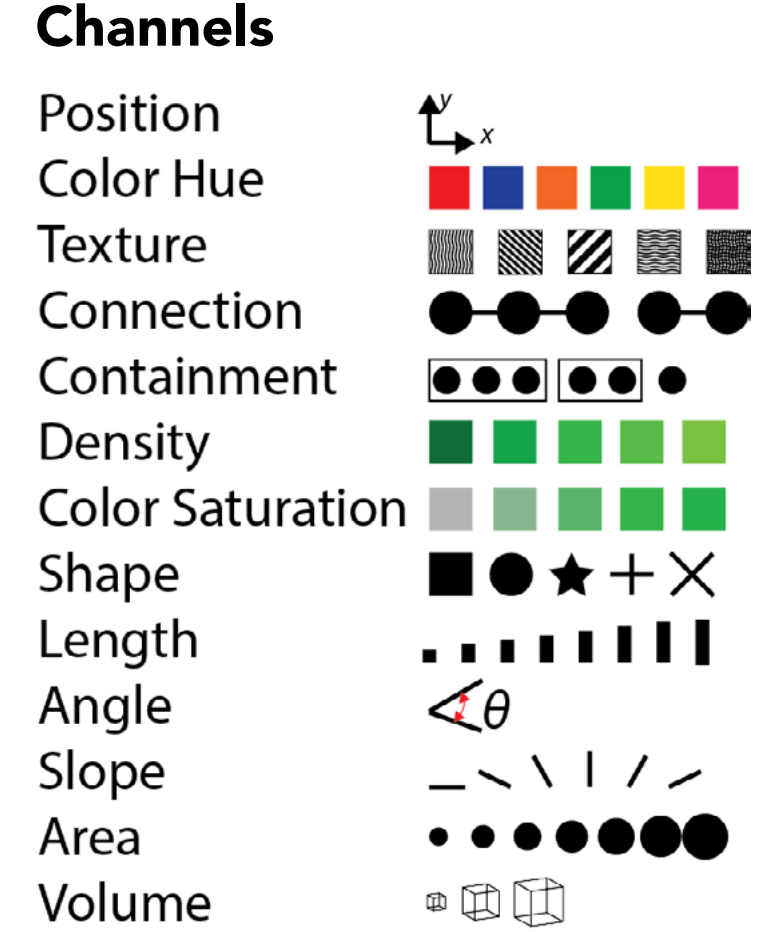
How well do these match, given the channel used?

2. Helps you evaluate charts systematically

E.g.,

How accurately do people perceive position?

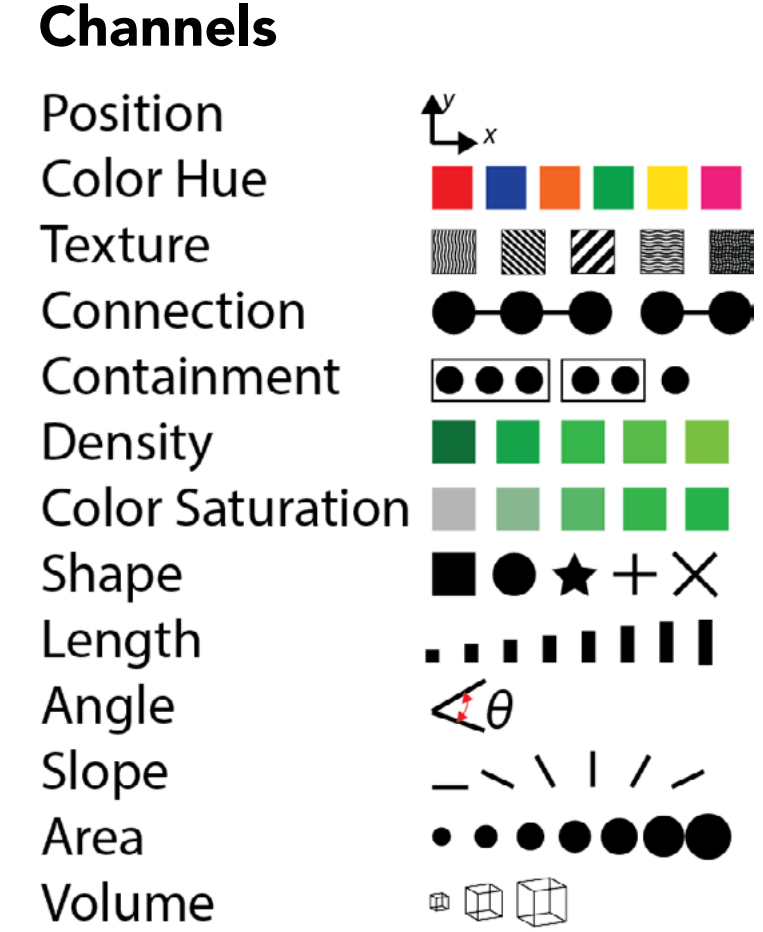
How accurately do people perceive area?



2. Helps you evaluate charts systematically

E.g.,

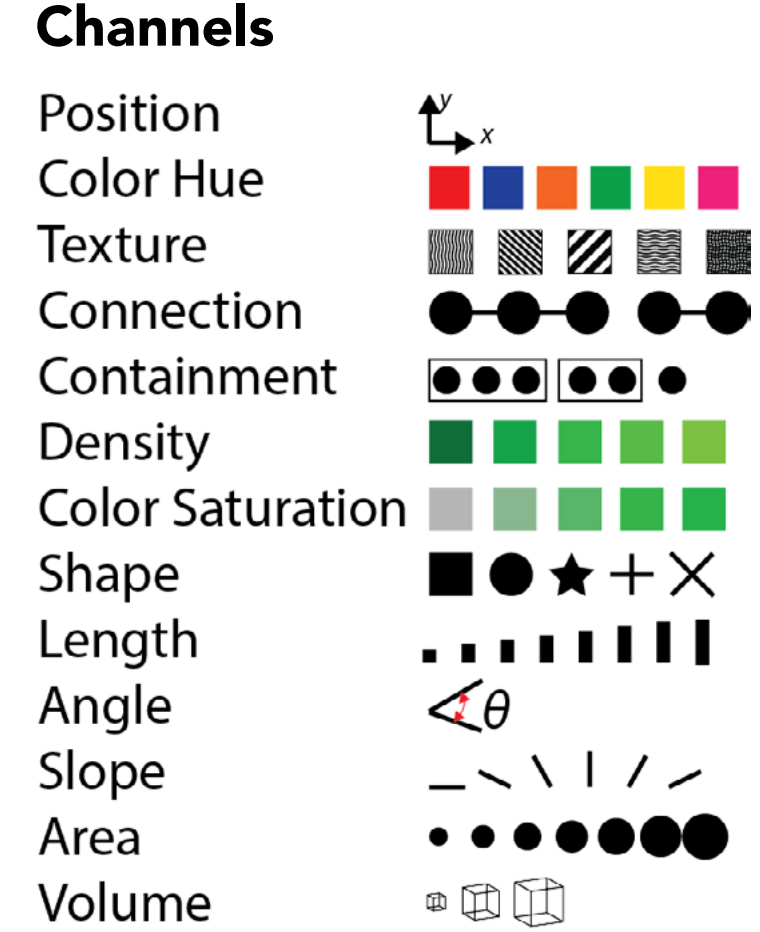
How accurately do people perceive position for quantitative data?
...for ordered data?
...for nominal data?
etc.



3. Helps you design charts systematically

E.g.,

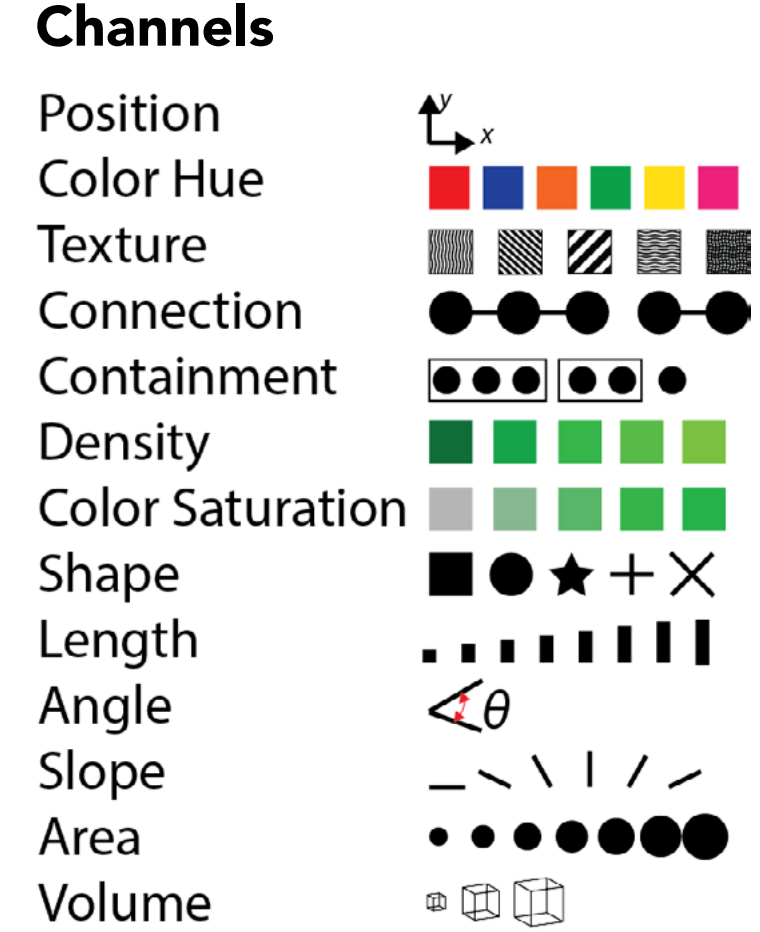
What channel is best for quantitative data?
...for ordered data?
...for nominal data?
etc.



3. Helps you design charts systematically

Work on perception informs these questions

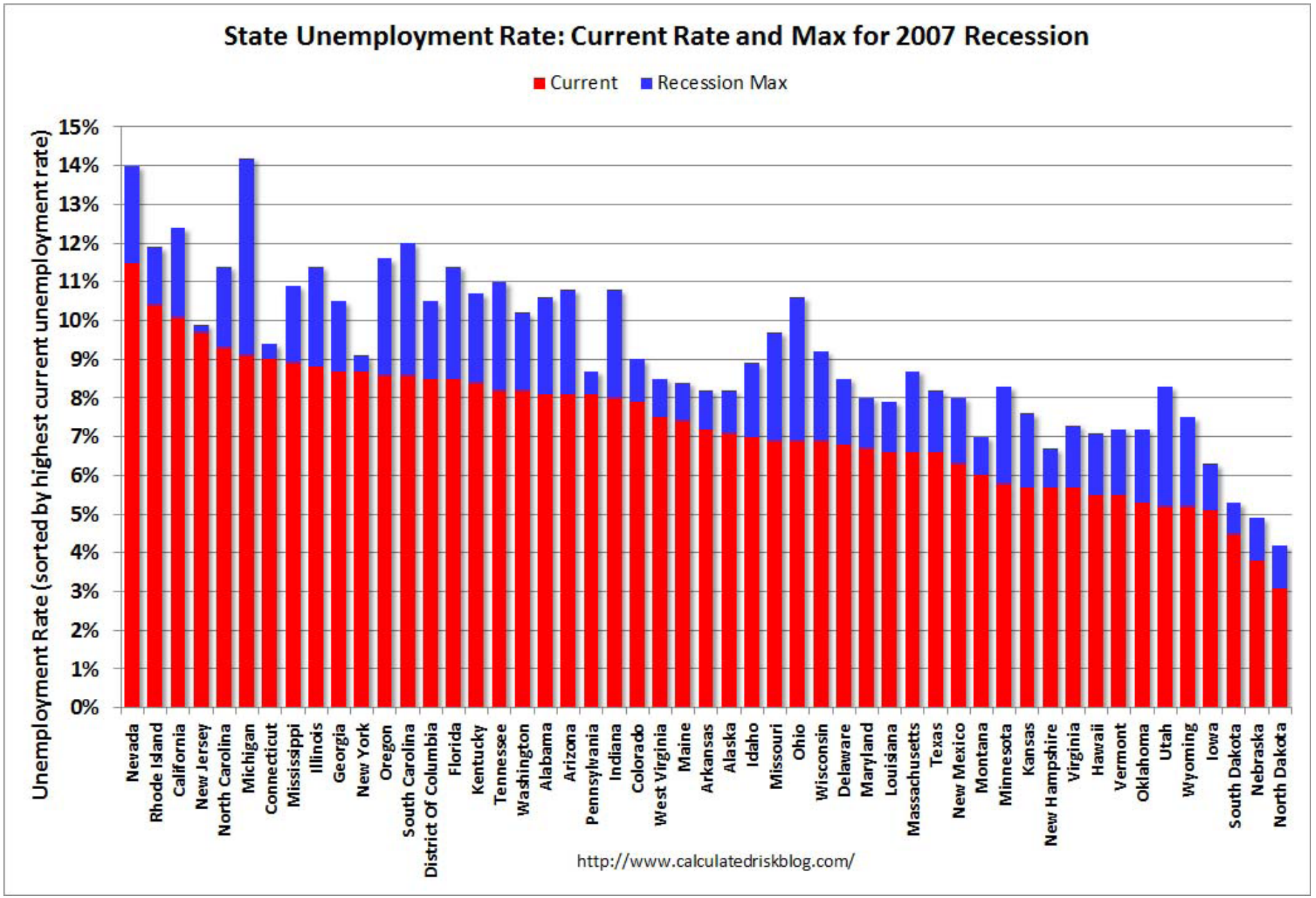
(next week's topic!)



Grammar of graphics summary

Think in data types, channels/encodings, and marks.

This will help you specify, evaluate, and design charts.



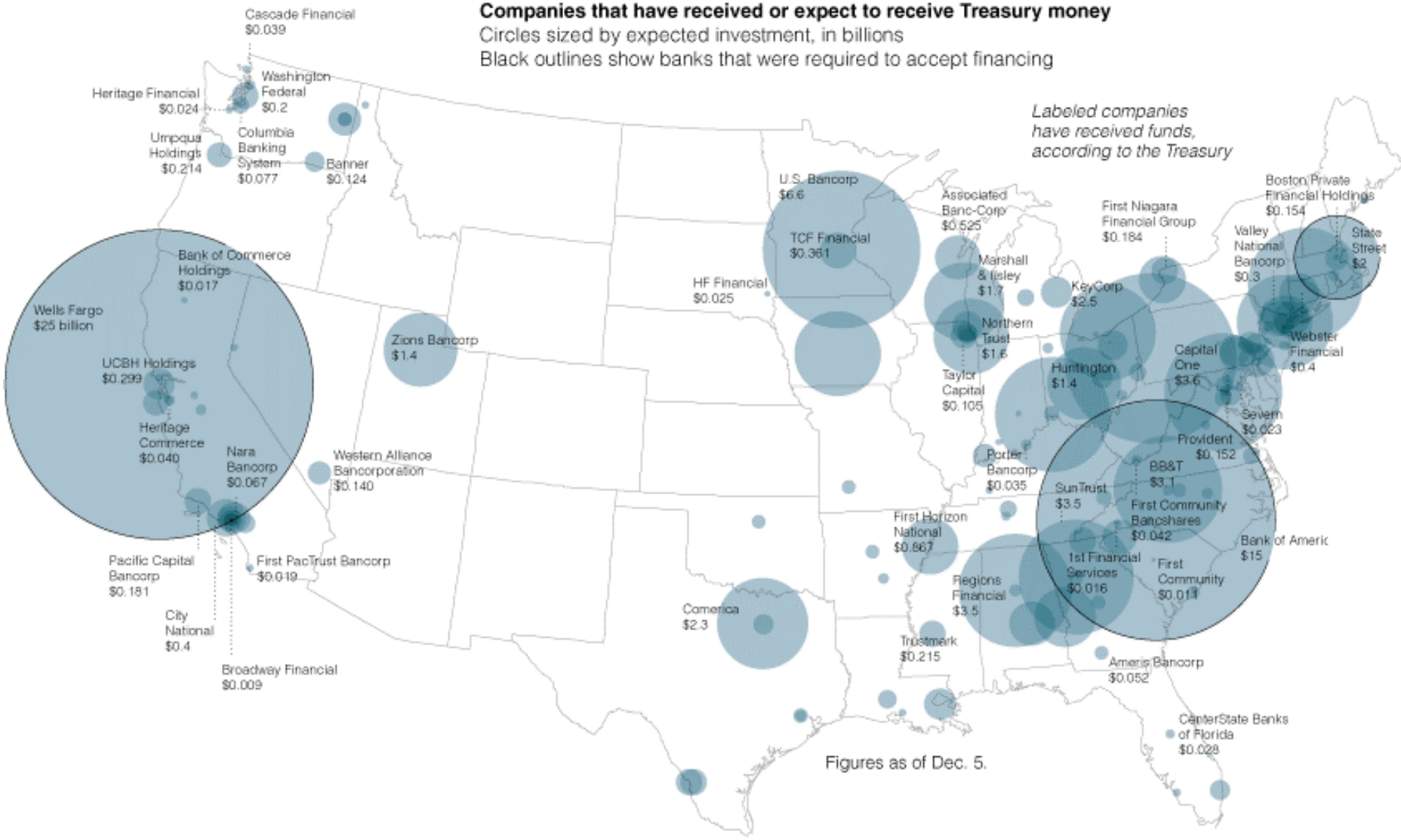
Group activity

What are the variables / types?

Channels / encodings?

Marks?

Is this effective?



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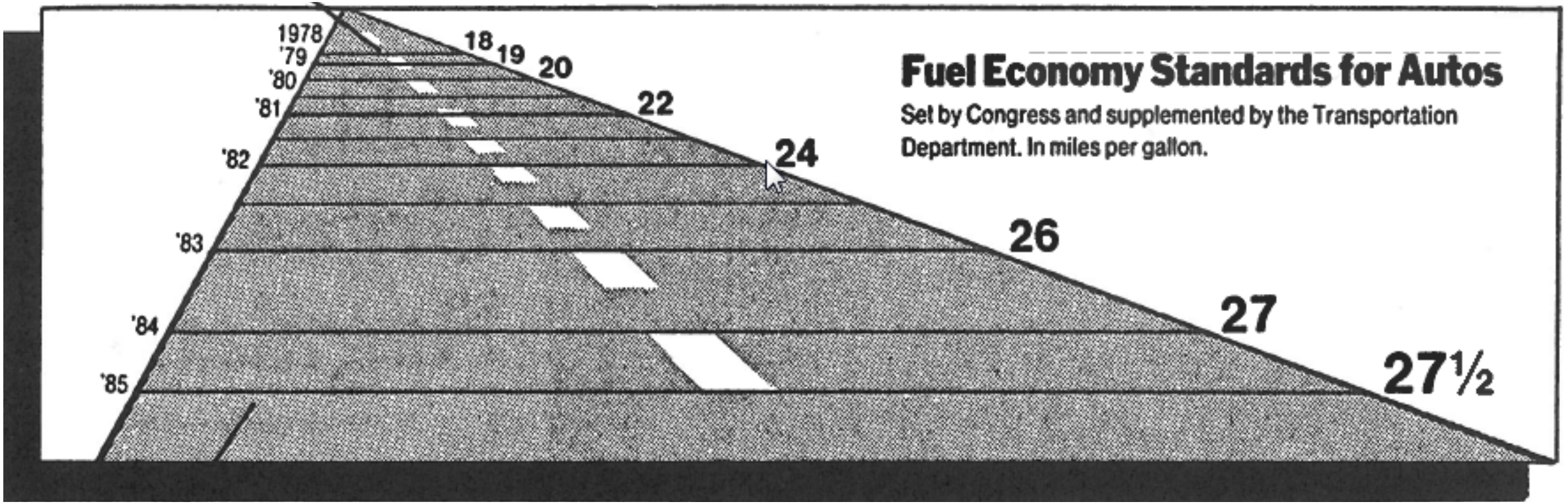

New York Times, August 9, 1978, p. D–2.

Group activity

What are the variables / types?

Channels / encodings? Marks?

Is this effective?

Group activity

What are the variables / types?

Channels / encodings?

Marks?

N.B.: skier size indicates price of six-day regional peaktime ski pass