

- see that normal distributions of data (or being normal enough) important
- only tools we have to assess this are histograms and maybe boxplots
- > a better tool is **normal quantile plot**:
 - plot data against what you expect if data actually normal
 - look for points to follow a straight line, at least approx
- ggplot code: aes sample; geoms stat_qq and stat_qq_line

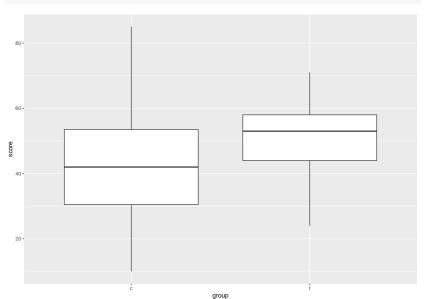
Packages

The usual:

library(tidyverse)

Kids learning to read

```
ggplot(kids, aes(x = group, y = score)) + geom_boxplot()
```



Get the groups separately

```
kids %>% filter(group == "t") -> treatment
kids %>% filter(group == "c") -> control
to check
treatment %>% count(group)
# A tibble: 1 \times 2
 group n
  <chr> <int>
1 t 21
control %>% count(group)
# A tibble: 1 x 2
 group n
  <chr> <int>
1 c 23
```

The treatment group

```
ggplot(treatment, aes(sample = score)) +
  stat_qq() + stat_qq_line()
 70 -
 60 -
 50
 40 -
 30 -
```

only problem here is lowest value a little too low (mild outlier).

Control group

```
ggplot(control, aes(sample = score)) +
  stat_qq() + stat_qq_line()
 80 -
 60 -
 40 -
 20-
```

This time, highest value a little too high, but again, no real problem with normality.

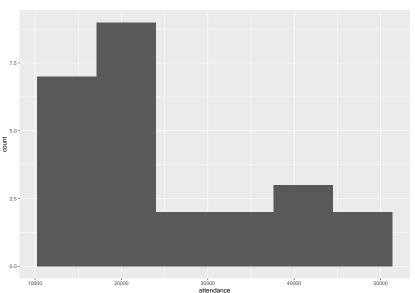
Facetting more than one sample

Use the whole data set and facet by groups

```
ggplot(kids, aes(sample = score)) +
  stat_qq() + stat_qq_line() + facet_wrap(~group)
 80 -
 60 -
 40 -
 20 -
```

Blue Jays attendances, skewed to right

ggplot(jays, aes(x = attendance)) + geom_histogram(bins = 0)



On a normal quantile plot

```
ggplot(jays, aes(sample = attendance)) +
  stat_qq() + stat_qq_line()
 50000 -
 40000 -
 30000 -
 20000 -
 10000 -
```

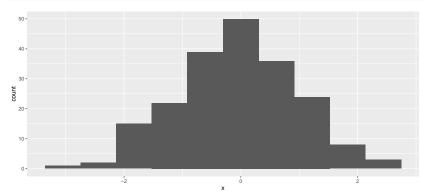
- Attendances at low end too bunched up: skewed to right.
- ▶ Right-skewness can also show up as highest values being too high, or as a curved pattern in the points.

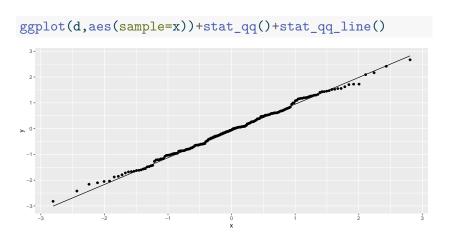
More normal quantile plots

- ▶ How straight does a normal quantile plot have to be?
- ► There is randomness in real data, so even a normal quantile plot from normal data won't look perfectly straight.
- ▶ With a small sample, can look not very straight even from normal data.
- ► Looking for systematic departure from a straight line; random wiggles ought not to concern us.
- Look at some examples where we know the answer, so that we can see what to expect.

Normal data, large sample

```
d <- tibble(x=rnorm(200))
ggplot(d, aes(x=x)) + geom_histogram(bins=10)</pre>
```



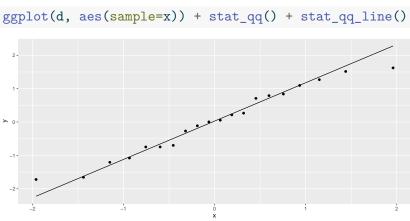


Normal data, small sample

Not so convincingly normal, but not obviously skewed:

```
d <- tibble(x=rnorm(20))</pre>
ggplot(d, aes(x=x)) + geom_histogram(bins=5)
count
 2-
```

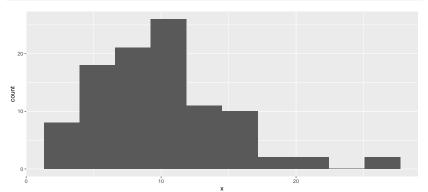
Good, apart from the highest and lowest points being slightly off. I'd call this good:



Chi-squared data, df = 10

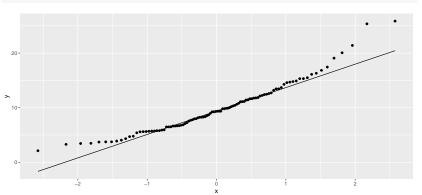
Somewhat skewed to right:

```
d <- tibble(x=rchisq(100, 10))
ggplot(d,aes(x=x)) + geom_histogram(bins=10)</pre>
```



Somewhat opening-up curve:

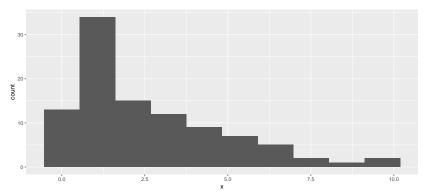
```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



Chi-squared data, df = 3

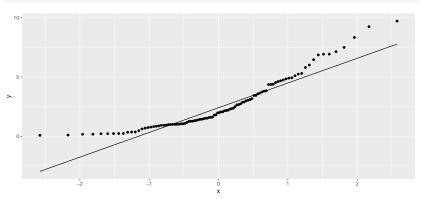
Definitely skewed to right:

```
d <- tibble(x=rchisq(100, 3))
ggplot(d, aes(x=x)) + geom_histogram(bins=10)</pre>
```



Clear upward-opening curve:

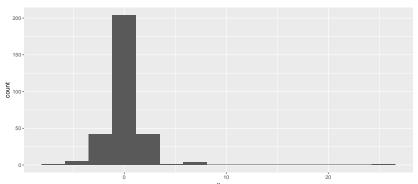
```
ggplot(d,aes(sample=x))+stat_qq()+stat_qq_line()
```



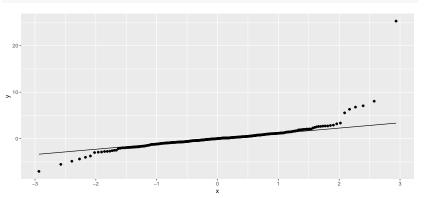
t-distributed data, df = 3

Long tails (or a very sharp peak):

```
d <- tibble(x=rt(300, 3))
ggplot(d, aes(x=x)) + geom_histogram(bins=15)</pre>
```



Low values too low and high values too high for normal.



Summary

On a normal quantile plot:

- points following line (with some small wiggles): normal.
- kind of deviation from a straight line indicates kind of nonnormality:
 - ▶ a few highest point(s) too high and/or lowest too low: outliers
 - lack else see how points at each end off the line:

	High points	
Low points Too low	Too low Skewed left Short tails	Too high Long tails
Too high	Short tails	Skewed right

ightharpoonup short-tailed distribution OK for t (mean still good), but others problematic (depending on sample size).