Data transformations and Non-Parameteric Methods

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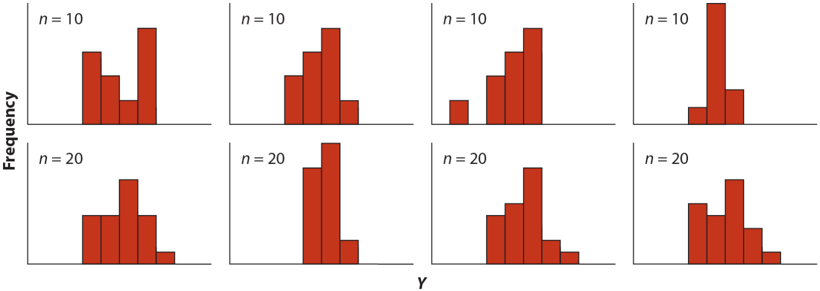
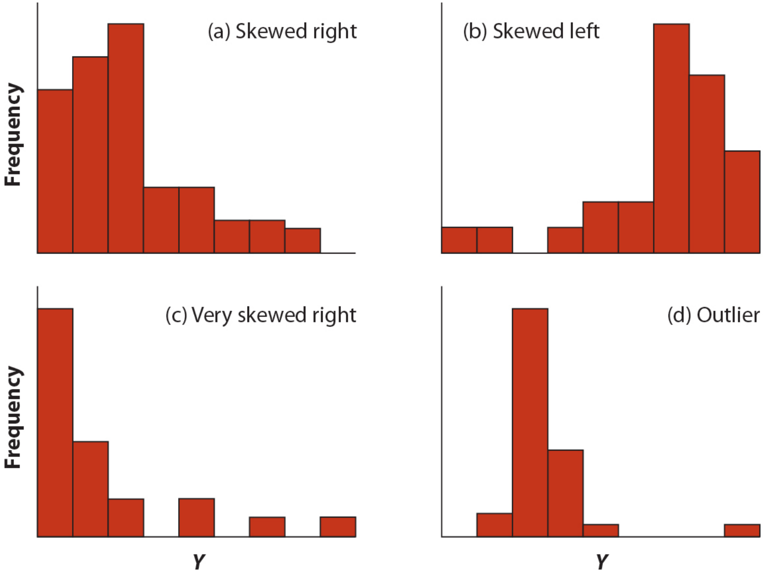
What do you do if your data is not normally distributed?

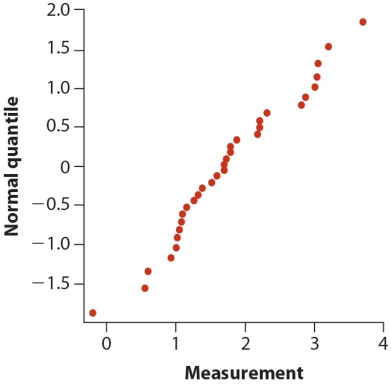
Is my data normally distributed?



Some non-normal distributions



Visual tools: normal quantile plot



R functions:

- `qqplot` and `qqline`, set argument `datax=TRUE` to plot observed data on x-axis like in figure above

Example data set: Comparing biomass between protected and unprotected marine sites

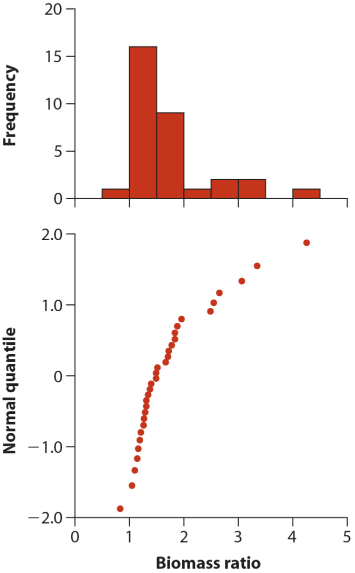
from Whitlock and Schluter:

- Halpern (2003) posed the equstion: Aare reserves effective in preserving marine wildlife?
- Compared biomass in each of 32 marine reserves to control (non-reserve) locations
- Calculate a "biomass ratio" as total mass of all marine plants and animals per unit area of reserve divdided by same quantity in unprotected control

Null and alternative hypotheses

- H_0: the mean biomass ratio is unaffected by reserve protection $(\mu = 1)$
- H_A: the mean biomass ratio is affected by reserve protection $(\mu \neq 1)$

Histogram and Normal quantile plot of biomass data



A formal test for normality: Shapiro-Wilk Test

Essentially a regression of ordered sample values on corresponding expected normal order statistics.

- H_0: the observed data is drawn from a population with normally distributed values
- H_A: the observed data is a drawn from a population where distribution is not normal

Compare Shapiro-Wilk test statistics to expected sampling distribution under H_0.

- P-value $<$ significance threshold, $\alpha \rightarrow$ evidence reject null hypothesis

R function:

- `shapiro.test`

Data transformations

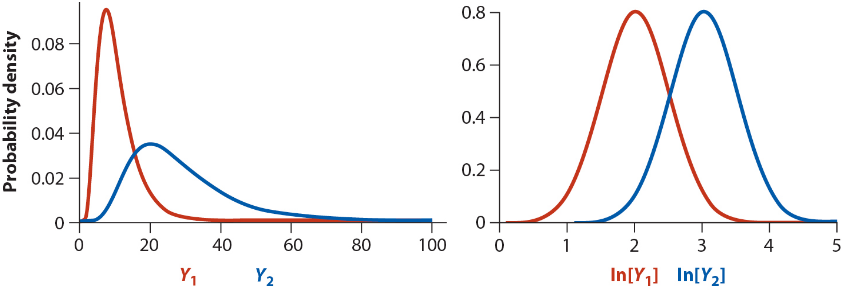
Log transformation

$$X' = \ln[X]$$

Tends to work well when:

- The data are all positive
- The frequency distribution is right skewed
- The data span several orders of magnitude
- The measurements are ratios or products of variables
- e.g. morphological measures such as body mass, length

Log transformation, cont.



Generate log transformation of biomass ratio data set

Cautions re: Log transformation

- $\bar{X}' \neq \ln[\bar{X}]$
- Often will do analyses in log transformed data, and then back transform to original scale to report *geometric mean* and CIs to facilitate interpretation

Arcsine transformation

$$X' = arcsin[\sqrt{X}]$$

- Used when data are proportions
- Values must be in range 0-1, divide by 100 if working with percentages

Example:

- Average percent of Senecio integrifolius flowers producing seeds at six different field sites (Widen 1993): 29.8, 44.2, 58.3, 83.0, 78.2, 72

Other transformations

Square-root transformation, $X' = \sqrt{X + 1/2}$

- Used for count data (number of eggs laid, number of bacterial colonies, etc)

Square transformation, $X' = X^2$

- left skewed data

Natural exponential function, $X' = e^X$

- alternative for left skewed data

Reciprocal transformation, $X' = \frac{1}{X}$

- right skewed, all data points have the same sign

Non-parametric tests

Sign test (alternative to one-sample t-test)

- Non-parameteric alternative to one-sample t-test
- Tests whether median of a population equals a null hypothesized value
- not very well powered

R implementation

- can be done as a binomial test or using `signmedian.test` package

Mann-Whitney U-test (alternative to two-sample t-test)

- Non-parameteric alternative to two-sample t-test
- Basic algorithm
- combine data from both groups rank all data from smallest to largest
- Calculate a statistc, U, which summarizes sum of all pairwise comparisons of ranks between the two groups
- Compare observed U statistic to sampling distribution of U under null hypothesis of no difference in ranks between groups
- Equivalent to a test called “Wilcoxon rank-sum test”

R implementation

- `wilcox.test`

Kruskal-Wallis test (alternative to ANOVA)

Spearman’s rank correlation

Assumptions of non-parametric tests

Power of non-parametric tests