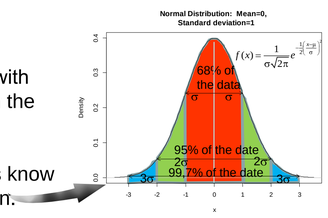
Are my data normal?

Comino Cortijo, C.*; Garrido Pampliega, N.; Zucchet, E. *****

Introduction

What is normality?

- It's a kind of statistic distribution, used with continuous variables, that depend only on the mean (μ) and standard deviation (σ).
- It's symmetric and bell-shaped.
- When representing it, we obtain what is know as a Normal curve or Gaussian distribution.



Is the Normal very normal in Biology?

Lots of biologic variables are the result of the sum of several independents features. As it explains the Central Limit Theorem, sums of that large number of variables will be distributed following the Normal law.

Why testing normality?

Normality is one of the more common assumptions made in the development and use of statistic procedures. Geary (1947) shows that probabilities derived from the well-known analyses of variance and other "small sample" tests, which postulate universal normality, may differ seriously from the true probabilities when the universes are non-normal.

- In this poster, we want to show you successive steps in the analysis of normality, exemplified with our own data, studying the effect of testosterone on the length of the fingers.

- Finally, we'll use simulated data in order to study the effectiveness of some tests of normality.

- Run tests of normality, but, be cautious, highly influenced by sample size!

Thode (2002) presents more than 40 normality test. But our software available for tests were:

- Lilliefors (Kolmogorov-Smirnov **K-S**) Correction of the famous K-S test that studies the maximal absolute difference between empirical and hypothetical cumulative distribution function.
- Shapiro-Willk's (**S-W**): It compares the estimated variance using moments and the one obtained from the slope of the Q-Q plot.
- Shapiro-Francia (**S-F**): Squared correlation between the ordered sample values and the (approximated) expected ordered quantiles from the standard normal.
- D'Agostino (**D'A**) This test has the null hypothesis of skewness should be equal to zero.
- Cramer-von Mises (**C-M**): EDF goodness of fit: $n\int_{-\infty}^{\infty}(F_n(x)-\Phi(x))^2\psi(\Phi(x))d\Phi(x)$ with $\psi(\Phi(x))=1$.
- Anderson-Darling (**A-D**): Like Cramer-von Mises with $\psi(p)=(p\cdot(1-p))^{-1}$
- Jarque_Bera (**J-B**): the test is based on a join statistic using skewness and kurtosis coefficients.
- Pearson chi-square (**P-Chi**): Chi-square goodness of fit of counted and the expected observations in class *i*. The classes are build is such a way that they are equiprobable under the hypothesis of normality

- For processing data we used the following statistical software: SPSS v20 and R v2.15.0.

Material and Methods

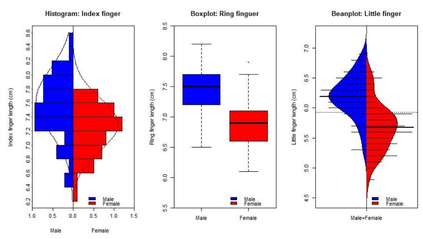
Our study

- Measurement of the four fingers (index, middle, ring and little) of the dominant hand in 98 adult people, randomly selected (48 ♂, 50♀).
- As a measuring device we manufactured a *finger-meter.*

Methods for studying normality

- Look at the distribution! Does it appear bell shaped?

For example



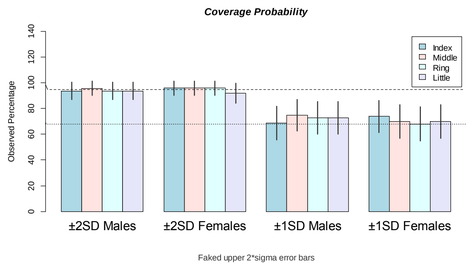
- Compute descriptive summary measures—are mean, median, trimed mean similar? – are skewness and kurtosis near zero?

For example

Measures for Females	Index finger	Middle finger	Ring finger	Little finger
Mean	7,246	7,460	6,192	5,678
Median	7,300	7,500	6,200	5,700
Trimed mean 5%	7,261	7,473	6,202	5,671
Skewness	-0,640	-0,533	0,600	0,266
Kurtosis	0,193	0,160	-0,214	-0,064

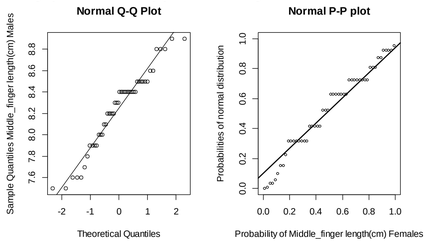
- Do 2/3 of observations lie within 1 std dev of the mean? Do 95% of observations lie within 2 std dev of the mean?

For example



- Look at a normal probability plot—is it approximately linear?

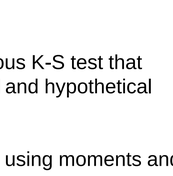
For example

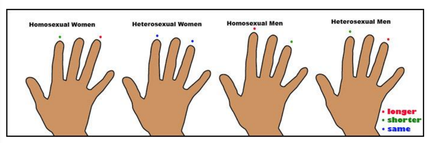


Results

Our data

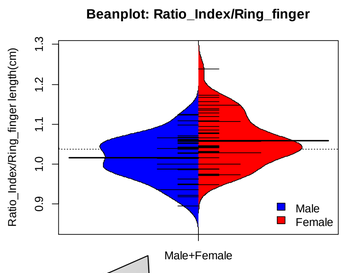
- We had been studying the ratio between index finger length and the ring finger length (2F:4F), according to sex.





- Scarbrough and Johnston (2005) tested that this ratio indicates the level of testosterone during gestation.

- As a preliminary to the comparison by gender, we have analyzed the normality of the sample observed following the described methodology.



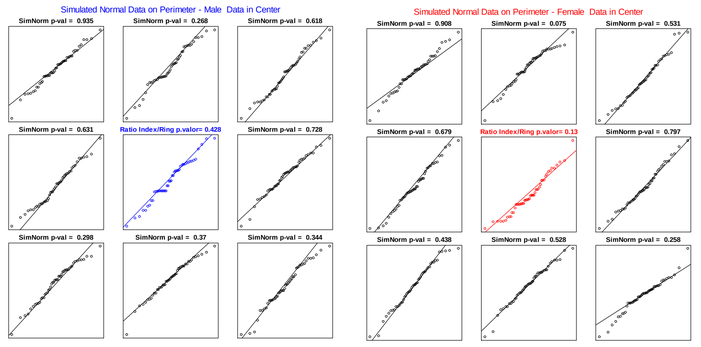
Measures	Ratio Index/Ring fingers	
	Males	Females
Mean	1,015	1,058
Median	1,013	1,045
Trimed mean 5%	1,015	1,055
Skewness	-0,090	0,566
Kurtosis	-0,352	0,075

We can appreciate a slight mixture of distributions in each gender. ***Could this show differences in levels of testosterone in each sex?***

Mean, median and trimed mean are similar in each group. Skewness and kurtosis are not significantly (α=0.05) different from zero.

Ratio Index/Ring fingers	± 1sd ~68%	± 2sd ~95%
Male	75% $I_{95\%}$ [61,4-85,7]	93% $I_{95\%}$ [83,9-98,4]
Female	64% $I_{95\%}$ [50,1-76,3]	98% $I_{95\%}$ [90,5-99,9]

The probability coverage is correct!

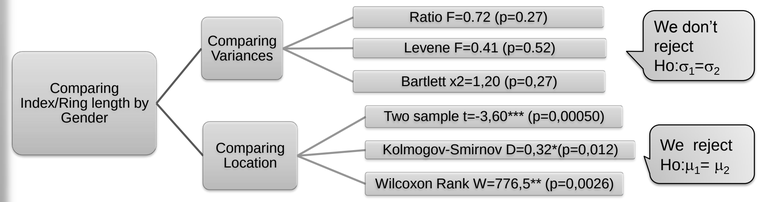


We observed a good fit to the line of the Q-Q normality plot of our data. The behavior is similar to the Normal data simulated on the perimeter. The S-W test does not reject normality.

There are no test rejecting the null hypothesis of normality for α=0,05, so we proceed to the gender comparison assuming normality in each group.

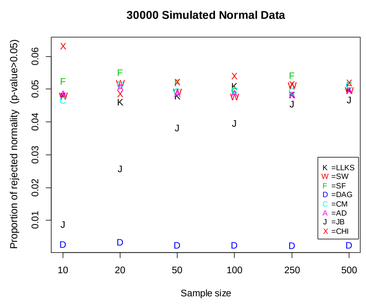
	K-S	S-W	S-F	D'A	C-M	A-D	J-B	P-Chi
Male n=48	D=0,11 *p=0.13*	W=0,97 *p=0.42*	W'=0,97 *p=0.47*	X^2=0,25 *p=0.88*	W"=0,09 *p=0.14*	A=0.49 *p=0.21*	Jb=0.44 *p=0.80*	P=4,5 *p=0.72*
Female n=50	D=0,11 *p=0.07*	W=0,96 *p=0.13*	W'=0,96 *p=0.12*	X^2=2.96 *p=0.22*	W"=0,09 *p=0.11*	A=0.57 *p=0.13*	Jb=2.51 *p=0.28*	P=12.8 *p=0.07*

- Now, we present the results of comparing the ratio Index/Ring by gender:

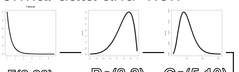


Simulated data

- Comparison of efficacy of the normality test using normal data and non-normal distributions.



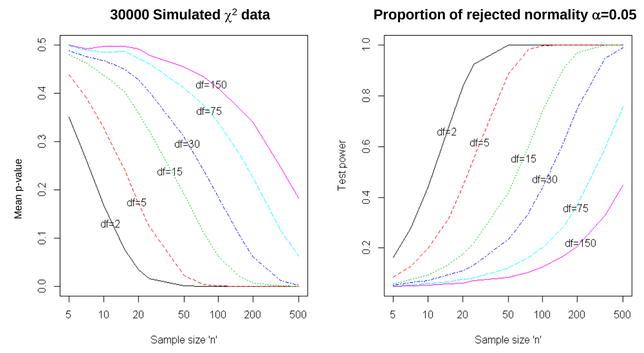
Non-Normal



N=50	F(2,20)	Be(8,2)	Ga(5,10)
K-S	0,673 *(6)*	0,389 *(6)*	0,328 *(6)*
S-W	0,889 *(1)*	0,734 *(1)*	0,587 *(1)*
S-F	0,861 *(2)*	0,664 *(2)*	0,556 *(2)*
D'A	0,409 *(8)*	0,165 *(8)*	0,204 *(8)*
C-M	0,803 *(4)*	0,524 *(4)*	0,423 *(4)*
A-D	0,843 *(3)*	0,605 *(3)*	0,481 *(3)*
J-B	0,581 *(7)*	0,390 *(5)*	0,412 *(5)*
P-Chi	0,746 *(5)*	0,309 *(7)*	0,207 *(7)*

Proportion of rejected simulated samples, *n*=50, α=0,05; 30000 replications. *(Order)*

- We show the results of the test we found powerful; Shapiro-Wilks, with the results of 30000 replicates χ^2 samples, sizes *n*: from 5 to 500 and *df*: form 2 to 150.



Conclusions

- In order to investigate the normality of some data, we **recommend** to use both the **descriptive** part and the **tests.**

- As Shapiro et al (1968) conclude, our simulations established that **S-W** is the **most powerful test** we have studied.
- With **S-W** we found the **expected behavior** of the test based on sample size and the deviation from normal with the *df* of the χ^2.
- **D'Agostino**'s test (1970) presents **difficulties** in calculating the p-value.
- In case of **non-normality** we can try the Box-Cox **transformation**: estimating the power (λ) to which the variable has to rise so that the data are normal: $y'=(y^{\lambda}-1)/\lambda$ if $\lambda\neq0$; $y'=\log(y)$ if $\lambda=0$.
- After testing normality in our experience, ratios 2F:4F, we conclude the **existence of statistically** significant **differences** (α=0,05) between gender…*Maybe for the testosterone effects!*

References

Box, G. E. P. and Cox, D. R. "An analysis of transformations". *Journal of the Royal Statisistical Society, Series B*. **26**: 211-46. 1964.

D'Agostino, R.B. "Transformation to Normality of the Null Distribution of G1".*Biometrika.* **57**: 679-681. 1970.

Geary, R.C. "Testing for Normality". *Biometrika.* **36**: 68–97. 1947.

Scarbrough, P.S. and Johnston, V.S. "Individual differences in women's facial preference as a function of digit ratio and mental rotation ability". *Evol. Hum. Behav*. **26**: 509–526. 2005.

Shapiro, S.S.; Wilk, M.B. and Chen, V. "A Comparative Study of Various Tests for Normality". *JASA*. **63**: 1343–72. 1968.

Thode Jr., H.C. "Testing for Normality". New York: Marcel Dekker. 2002.

Acknowledgments

- This work has been supported by Col·legi Oficial de Biòlegs de la Comunitat Valenciana.
- We thank to the numerous classmates and friends who took part in this experience.

*cincocor@alumni.uv.es; **nugapam@alumni.uv.es; ***enzuc@alumni.uv.es - *Grade in Biology 1st B 2012*