Comparison of location parameters among 3 or more groups of identical individuals

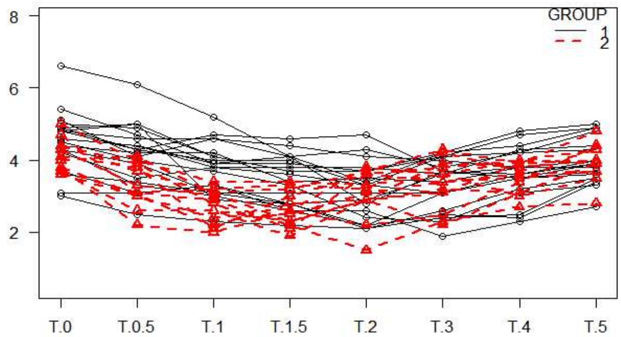
- Comparison of location parameters among 3 or more groups of different individuals → One-way ANOVA or Kruskal-Wallis test
- If all groups are composed of the same individuals?
→ Repeated-measures ANOVA or Friedman's test
- Data should be given as wide-format for EZR
(Data at different times → Different variables
*1 line means 1 individual)
Names of time-dependent variables must be given as alphebetical order. If not, rename using [Active data set] [Variables] [Rename variables]
- Flow: Read data → Draw graph → Statistical analysis
See, (1) The effects of Group(s), Time, Interaction from ANOVA table, (2) Check sphericity (Null-hypothesis: equal variances among time), (3) If (2) is significant, see G-G or H-F adjustment

Example 1. Skin electric potential (mV) after various stimuli in 8 individuals

- Read data from:
http://minato.sip21c.org/hypno-psycho01.txt
- Draw graph of raw data:
[Graphs][Line graph (Repeated measures)]
select → calmness, despair, fear, happiness
- Looks not normally distributed. Values are not independent (→ One-way ANOVA is not appropriate). And, the intra-individual factor is not “time”.
- Null-hypothesis: Skin electric potentials are not different by the kind of psychological stimuli
- Statistical analysis:
[Nonparametric tests] [Friedman test]
select → calmness, despair, fear, happiness
Friedman chi-squared = 6.45, df = 3, p-value = 0.09166 (NS)

Example 2. Changes of plasma inorganic phosphate after OGTT for 33 individuals

- Reading data: [File][Import data][Read Text Data From Flie, Clipboard, or URL]
  Name: ogtt02, From: URL, Delimiter: tabs
  URL: http://minato.sip21c.org/ogtt02.txt
- Draw graph of raw data:
  [Graphs] → [Line graph (Repeated measures)]
  Repeatedly measured data: T.0, T.0.5, …, T.5
  Grouping variable: GROUP
- 2 GROUPs
  1: Control
  2: Obesity
- Checking the effect of TIME, GROUP, and interaction



Example 2. (cont'd)

- [Statistical analysis] [Continuous variables] [Repeated measures ANOVA]
- Repeatedly measured data: T.0, T.0.5, …, T.5
  Grouping variable: GROUP
- ```
  Univariate Type III Repeated-Measures ANOVA Assuming Sphericity
                         SS num Df Error SS den Df          F    Pr(>F)
  (Intercept)        3173.3      1   73.581     31 1336.9260 < 2.2e-16 ***
  Factor1.GROUP        13.2      1   73.581     31    5.5464   0.02503 *
  Time                 42.3      7   36.438    217   35.9602 < 2.2e-16 ***
  Factor1.GROUP:Time    9.4      7   36.438    217    7.9881 1.255e-08 ***
  ---
  Signif. Codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
  ```
- ```
   Mauchly Tests for Sphericity
                     Test statistic    p-value
  Time                      0.05137 9.4322e-08
  Factor1.GROUP:Time        0.05137 9.4322e-08
  ```
- ```
  Greenhouse-Geisser and Huynh-Feldt Corrections
   for Departure from Sphericity
                     GG eps Pr(>F[GG])
  Time               0.57374  < 2.2e-16 ***
  Factor1.GROUP:Time 0.57374  8.868e-06 ***
  ---
  Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
  ```

Or, do Two-way ANOVA
  ```

Example 2. (cont'd)

- Non-parametric test is still possible
- [Statistical analysis] [Nonparametric test] [Friedman test]
  Select variables: T0, T0.5, …, T5
- Friedman chi-squared = 114.8377, df = 7,
  p-value < 2.2e-16

Example 3. Change of systolic blood pressures (mmHg) after drug admin.

- Read data: http://minato.sip21c.org/sbp01.txt
- Rename the name of variable from T.1 to S1
- Draw graph of raw data
  Repeatedly measured data: S1, T0, T1, …, T8
- Friedman test: p=0.029 → SBP significantly changes by time after drug administration.
- Repeated measures ANOVA:
  [Statistical analysis] [Continuous variables] [Repeated measures ANOVA]
  Repeatedly measured data: T0, T1, …, T5
  * More variables than subjects are not allowed

Repeated or Inter-rater agreement of categorical variables (Chap.13)

- When ordered or categorical variables were measured repeatedly or evaluated by multiple raters (observers), the result can be summarized as two-dimensional cross tabulation.
- However, common statistical testing for two-dimensional cross table like chi-square test or fisher's exact test is completely inadequate, because repeated or inter-rater measurements are clearly not independent.
- We have to test (1) the agreement significantly exceeds the expected one by chance, or (2) the agreement significantly worse than the expected one by chance.
  - (1) can be done by Kappa-statistics
  - (2) can be done by McNemar's test

Kappa-statistics and McNemar's test

- Kappa statistics
  - Please assume the clinical test repeated 2 times, summarized as 2 by 2 cross table.
  - The agreement probability Po is (a+d)/(a+b+c+d).
  - If the agreement of the 2 test is perfect, b=c=0 (Po=1). When the tests completely disagree, a=d=0 (Po=0).
  - If the agreement is completely by chance, expected agreement probability Pe is {(a+c)(a+d)/(a+b+c+d)+(b+d)(c+d)/(a+b+c+d)}
  - Kappa statistics can be defined as (Po-Pe)/(1-Pe)
  - library(fmsb)
    Kappa.test(matrix(c(12, 2, 4, 10), 2, 2))
  - In EZR, [Statistical analysis]>[Accuracy of diagnostic test]>[Kappa statistics for agreement of two tests]
- McNemar's test
  - Evaluate the significant change of binary variable (pos/neg) between before/after intervention
  - The result is still 2 by 2 cross table.
  - $X^2_0 = (b-c)^2/(b+c)$, obeys chi-sq dist with d.f.=1
  - mcnemar.test(matrix(c(a, c, b, d), 2, 2))
  - By EZR, from raw data, see right.
  - Extended version is Bhapker's test (It's available as bhapker() in irr package).

Test	Retest	
	Positive	Negative
Positive	a (=12)	b (=4)
Negative	c (=2)	d (=10)