this issue

"Statistical Analysis

for Neurofeedback"

Neuro-Eastern

EDITOR-IN-CHIEF'S NOTE

Assoc. Prof. Dr Aamir Saeed Malik

The Editor-in-Chief, NEURO-EASTERN

aamir_saeed@petronas.com.my

"Neurofeedback Training"

This is the 7th issue of NeuroEastern. As it is a bi-monthly newsletter of APNA, the 7th issue is for January and February 2017. To start with, I would like to remind that Neuro-Eastern is a free platform to share your research and/or clinical experience and your current research projects with other researchers. Therefore, I would like to invite all the interested readers of the Neuro-Eastern newsletter to share your expertise in neurofeedback or related current projects by writing a short article, which can be included in the next issue, and explore new tools for data analysis, especially EEG analysis.

The main article in this issue is on 'Neurofeedback Training'. The fundamentals of neurofeedback and its various applications have been reported in previous issues of NeuroEastern. In this article written by Yasir Hafeez, he briefly highlights the neurofeedback training, its basic procedure, and various available tools for conducting neurofeedback interventions, such as brain trainer and brainMaster. A few good references are provided of related work of neurofeedback. In addition, he provides a brief review on neurofeedback in mode disorders, such as stress and anxiety.

The resources pages discuss statistical Analysis using SPSS (Statistical Package for Social Sciences), a statistical analysis software tool developed by the IBM Corporation USA. It is one of the most important tools for statistical analysis in experimental research, including biomedical, neuroscience, and neuropsychology.

The user interface of SPSS is user friendly, and the web is rich in manuals and guides for using SPSS. The SPSS includes many good features, which are necessary for data exploration, data reduction, clustering, modeling, statistical testing, and data visualization for report writing. The SPSS is a good source for data analysis and results interpretation, especially in experimental research. However, the software is not free and needs a license.

We look forward to your feedback on this issue.

Aamir

APNA

Asia Pacific Neuro-biofeedback Association (APNA)

President's Message

Dr. Kenneth Kang

Head of Spectrum Learning

It is my sincere pleasure to welcome you to join APNA.

APNA was established to provide an oversight of the field of neurofeedback and biofeedback, so as to promote and expand it, as well as to safeguard consumer interests.

I would like to express my deepest gratitude to the practitioners and researchers who have come together to help make the establishment of APNA possible. With that, I also want to extend my warmest invitation to anyone who is passionate about this field to come join us and grow this field, hand in hand, with the community for the benefit of mankind.

Brief Description

APNA is a non-profit organization for the purpose of joining the expertise of clinicians and researchers who are involved in health care research, and the clinical applications of neurofeedback and biofeedback for serving society. There is a growing number of professional clinicians, and biomedical and computing engineers, who have expertise in medicine, psychology, therapy, engineering, and the development of new advanced computing solutions to biomedical problems.

These diverse experts started sharing their expertise, joint research collaborations, organizing joint events, and developing their professional networks, under the umbrella of APNA. These activities are at initial stages and expected to peak in the future, including all the countries in the Asia Pacific region. It is very encouraging that the growing network of these professionals is promoting the clinical use of neurofeedback and biofeedback interventions to the general public for maximum benefits. Consequently, it will help people consult certified practitioners of neurofeedback rather than non-certified consultants.

VISION

1. To deepen our understanding of Asian mindfulness and meditation techniques and its health benefits with rigorous science

2. To promote its application in society to improve health, performance and quality of life

MISSION

1. To promote research collaboration between researchers, clinicians and the community

2. To promote professional clinical use of neurofeedback and biofeedback in the AP region

3. To promote awareness of the benefits of neurofeedback and biofeedback to the general public

NEUROFEEDBACK TRAINING

By **Yasir Hafeez**
Email: yasir_hafeez@ymail.com

Introduction

Neurofeedback is also known as EEG-Biofeedback, which provides a feedback of the brain's electrical activity to the person by using real-time audio and/or video, so that the brain can improve its functionality. Neurofeedback involves recording, analyzing, and presenting the results of measured electroencephalogram (EEG) analyses to the subject in the form of a reward (play/pause of the content) to show the changes in the brain's electrical activity [1]. The basic principle of neurofeedback is to measure the brain activity (EEG signals) using electrodes connected on the scalp, identify the brainwaves using quantitative EEG analysis, and then provide the subject with a feedback content as a reward, depending on the desired levels of the brainwaves. In neurofeedback systems, EEG data is used to monitor real-time brain activities [2]. The feedback is provided to the user in the form of a visual, audio, game, reading, or spell check. It can be implemented as a color change, bar increase/decrease, vibration, or sound, or it can be integrated into the Neurofeedback game as a character/object appearance, the target color in a shooting game, etc. The feedback determines the condition of the brain state, such as whether the power of the brainwaves is in the desired level of threshold or not [3]. In a simple way, neurofeedback creates a challenge for the brain, which triggers an adaptive change in the brain over a number of training sessions.

## Neurofeedback Training as a Treatment:

Neurofeedback or EEG-Biofeedback is a non-invasive technique. It is being practiced as a training for humans on how to control their brain activity. Several studies have uncovered the fact that neurofeedback training has restorative impacts in treating a number of neurological and psychological issues such as attention deficit hyperactivity disorder (ADHD), epilepsy, and some addictive cognitive disorders.

Neurofeedback is also found useful for the treatment of anxiety, stress, affective disorders, depression, fibromyalgia, obsessive-compulsive disorder, and also to enhance attention and memory performance in healthy subjects [4]. Neurofeedback training has also applied to healthy users. This training is demonstrated its ability to improve certain cognitive aptitudes [5]. The latter studies targeted the enhancement of the upper section of the alpha band (10-12 Hz), which is traditionally linked to performance [6]. There is evidence that shows that neurofeedback can lead to a long-lasting improvement in cognitive performance, and also in mental and emotional health.

Self-control, concentration, and organizational skills can be improved by neurofeedback training.

Neurofeedback Training for Stress:

Stress is not a disease when it is managed, controlled, and for a short duration. The brain produces different EEG patterns during stress conditions by producing excessive stress hormones. They tell the brain how to feel and react in different challenging and pressured situations. However, prolonged exposure to stress increases the strength of those brain patterns. The stronger the stress patterns are, the more difficult it is for the brain to revert back to a neutral, unstressed state. This is called chronic stress. In a chronically stressed situation, the performance of the brain is affected. So, the person underperforms almost in everything when he is stressed.

Figure 1: Brain Activity in Emotional States
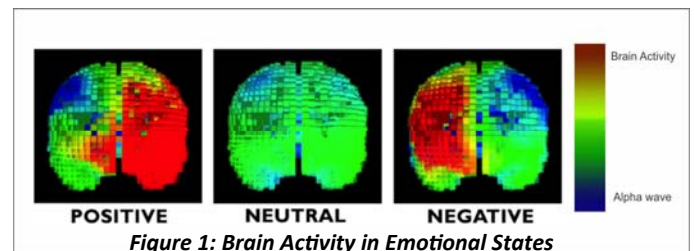
To reduce stress, medication is taken to suppress symptoms so that the brain can produce neutral patterns again. The problem we face is that our body becomes resistant to these medications, and we have to either overdose or switch medication. This is never a solution to this problem. Another unique, uncommon option to reduce stress is neurofeedback. It can give you the mental edge to respond to stress in an appropriate manner. Neurofeedback training is one the treatments of stress, which enables the subject to train themselves to control their brain activity during stress and anxiety [7]. Neurofeedback training can stabilize the central nervous system. It trains the central nervous system to enable stressful situations, and then get back to neutral, unstressed state. Neurofeedback enables the individual to self-control and trains them in the mental skills to respond and adapt appropriately to stress.

Researchers have found, in stress conditions, brain activity reduces more in the left hemisphere as compared to the right hemisphere in the prefrontal. Also, it is a known fact that normal, neutral, and unstressed brains show more alpha (8-12 Hz) frequency in the right prefrontal lobe as compared to the left-prefrontal.
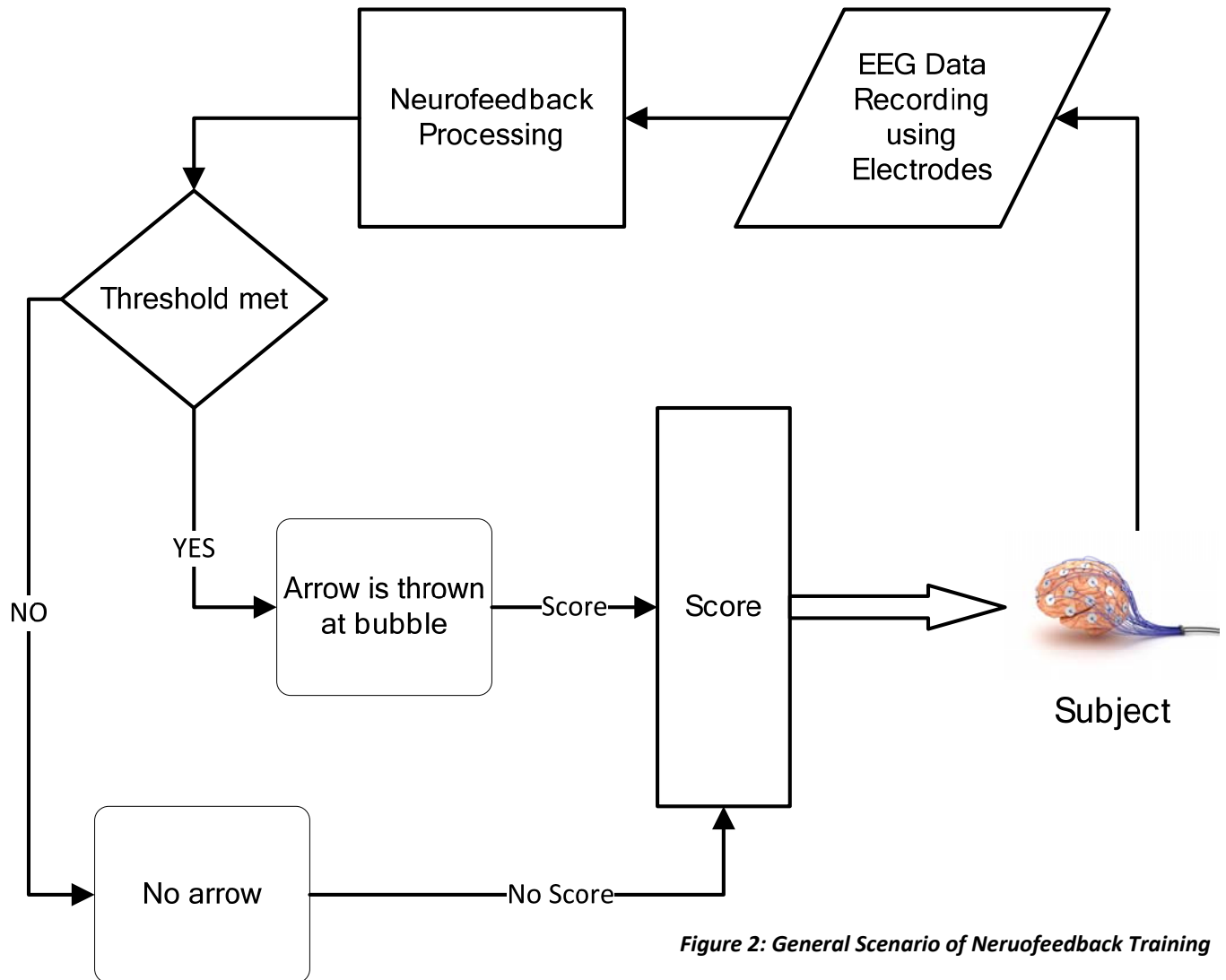
Figure 2: General Scenario of Neruofeedback Training

This is called alpha-asymmetry [8]. A number of neurofeedback training sessions under experienced therapists help patients to reproduce the more powerful alpha frequency waves in the right prefrontal during stress. Neurofeedback training helps the brain to naturally reproduce the desired brain activity patterns in the left and right hemispheres in stressful conditions.

There is research going on to provide a portable and handy neurofeedback system. That neurofeedback system will contain centralized clinical workstations to provide the patients' training and therapy at their workplaces to improve their performance under stress.

Stimuli (content) for Neurofeedback Trainings:

Neurofeedback training has been done by a number of researchers to train their subjects in mitigating their stress levels [9]. Beniodakis [7] and Peniston [10] have used audio as a neurofeedback stimulus to reduce the stress level. Mostly, audio is used as a content for neurofeedback training to reduce increased alpha in the left prefrontal and in the right occipital lobes [7].

Different content (games, reading a paragraph, audio, video, etc.) has been developed to make the training more attractive and to improve the treatment efficacy. The most used neurofeedback content for training the subjects in the treatment of ADHD are games and videos [11]. It is normally observed that theta increases and beta decreases [12] in youngsters with ADHD, as compared to developing youngsters. Increased theta (4-7 Hz) is associated with lower vigilance, and decreased beta (13-30 Hz) is associated with reduced attention [13]. Also, behavioral inhabitation is related to the sensorimotor rhythm (SMR; 12-15 Hz) [14]. As neurofeedback aims to reduce ADHD symptoms, such as diminished vigilance, attention, and inhibition. Common neurofeedback training protocols inhibit theta (4-8 Hz) and increase beta (12-20 Hz) or SMR (12-15 Hz) over the vertex Cz [15], [16]. A complete neurofeedback intervention typically comprises of 20-40 training sessions [16].

Neurofeedback has been observed to be an effective treatment for depression [17]. Choobforoushzadeh [18] used games and audio to decrease the alpha/theta ratio in the frontal lobe but did not include multiple brain lobes.

Neurofeedback devices:

There are a lot of neurofeedback devices available in the market by different vendors. Brainmaster has produces a variety of neurofeedback devices. The following neurofeedback devices are available by this company;

♦ Atlantis
♦ Discovery
♦ Freedom 24D and Freedom 7D are wireless EEG-headset
♦ 2EB
♦ Mini-Q II

Spectrum Learning Singapore has developed Brain-Trainer 4-channel and Brain-trainer 2-channel neurofeedback devices.

Figure 3: Spectraum Learning Neurofeedback devices

Some other popular brands of personal neurofeedback devices include:

• BrainLink
• Emotiv
• Mindwave Mobile
• Melon
• Muse
• NeuroSky
• Thync
• Versus
• Neurobit

Prices for headsets generally range from just under $100 to over $500. According to Deane Alban, a blogger, and researcher on bebrainfit.com, the less expensive options of these devices are often beset with technical problems, while the more expensive versions are more reliable.

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SPSS (Statistical Package for Social Sciences)

By: Soyaba Jawed
Email: soyaba@gmail.com

Introduction:

A statistical method has its importance in the area of neurofeedback. Designing and performing analysis for EEG experiments is a tedious task, leading to experts recommending known material based procedures. It is more convincing explaining the observations if there is a link between the results and existing published work with a statistical procedure. The question here is to choose the right statistical method. It also depends on what one is intending to do, for instance if the task on hand is to investigate event-related potentials (ERP), the focus will be on the peak of amplitudes and latencies in the ERP waveforms of electrodes in consideration [4]. On the other hand, investigating frequency based measures, such as amplitude, power, and power entropy of alpha, beta, delta, gamma, and theta band, the focus will be peak frequency of the certain band [4].

EEG metrics such as long-term memory, cognitive load, and attention can either be analyzed using frequency domain features of the EEG data or by investigating the peak amplitudes with respect to the onset of a certain event. To perform these statistical analyses, the SPSS software is used [6].

What is SPSS?

SPSS stands for the Statistical Package for the Social Sciences. It is the most popular data analyzing software among researchers from different fields. The input to SPSS is not type bound. SPSS is capable of dealing with any data type with a high complexity level. SPSS generates results using simple instructions in the form of tables, plots, graphs, and charts, etc., which represent the distributions and trends of descriptive and complex statistical analysis [7].

Functionalities of SPSS:

SPSS has a number of functionalities for the different areas of research. In the field of neurofeedback, the most used func-

tionalities of SPSS are parametric tests and non-parametric tests. Before describing these functionalities, this article presents how to get started with SPSS and the basic steps that one needs to perform for generating the desired results [7].

Getting started with SPSS:

To start with SPSS, first look for the icon on your desktop, double click on that, and follow the steps given below [1]. Click on the file button at the top and select the file open option, choose the data, and open the file. After creating or editing an open data file, the user must save the data file. To save the data file, click on file menu again and select save data file here. The user can save data file with any name of their choice.

To start a new file, click on file and select new file from drop down menu. Following are the most used windows by SPSS users: i) Data Editor, ii) the Viewer, iii) the Pivot, iv) Table Editor, v) the Chart Editor and vi) the Syntax Editor.

i) **Data Editor:** It has user entered data. Figure 1 shows the data editor.

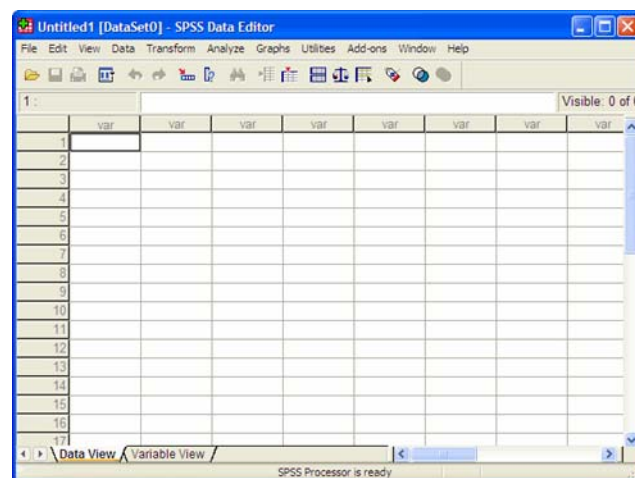ii).**Viewer:** It shows the results of the process data. Figure 2

Figure 1: Data Editor Window shows the

iii) **Pivot table editor:** This window edits the already entered tables.

iv) **Chart Editor:** The displayed charts and graphs in the viewer window can be edited using the chart editor.

v) **Syntax editor:** It is used to create SPSSS program. To execute the program, select run from the menu window. Figure 3 shows the editor window.

vi) **Closing SPSS:** To close SPSS, save your work and click exit.

Statistical techniques for neurofeedback using SPSS:

Neurofeedback utilizes the branch of statistics which is used to find the statistical difference among a number of groups [1, 2]. These tests have two types: 1) Parametric: These tests are applied on normally distributed data; 2) Non-parametric: Also known as distribution-free tests. These tests are applied to data which are not normally distributed. For neurofeedback, parametric tests such as t-tests and ANOVA are mostly used, which are also the focus of this article.

T-tests:

T-tests are used to compare the mean scores among two groups, such as females and males. They are also used for two sets of data collected at different time, such as before and after. T-tests are divided further into two types: 1) Paired sample t-tests: these tests are used to measure the score for participants at different instances of time (T1 and T2); 2) Independent sample t-tests: is used to compare the scores of two independent groups, for this test data is collection time is same but group of people is different. The following is the procedure to calculate a sample t-test using SPSS software.

Procedure for independent samples t-test using SPSS:

1. Select Analyse from the top menu. To compare mean select Compare means. Finally, select Independent-Samples T test.

2. Transport the **dependent (continuous)** variable to the Test variable box.

3. Transport the independent **variable (categorical)** variable into the section labeled **Grouping variable**.

4. Select the **define groups** and enter the numbers used in the data set for each group to code. For instance, if the data file has 1=males, 2=females, in the Group 1 box, enter 1, and in the Group 2 box, enter 2. In order to double check the codes used, right click on the **variable name** and select **Variable**. This will show the code information.
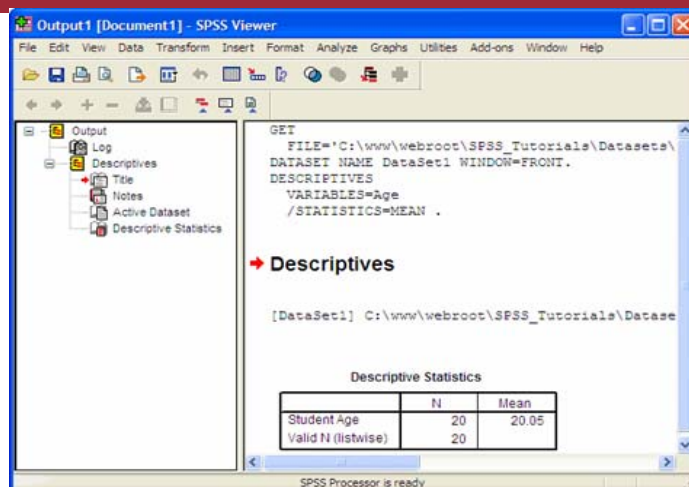

Figure 2: Viewer Window

5. Select **Continue** and **OK**. Figure 3 shows the independent t-test sample example.

Procedure for paired-sample t-test using SPSS:

1. Select **Analyse from the menu**, then click Compare **Means** follow by **Paired-Samples T test**.

2. Select the two variables that you want to compare for each subject and transport them to the box labeled **Paired Variables** by selecting the arrow button. Click on **OK.** Figure 4 shows the paired t-test sample example.
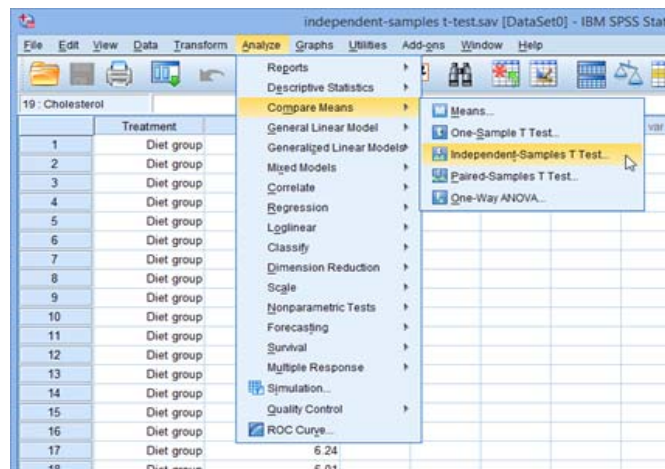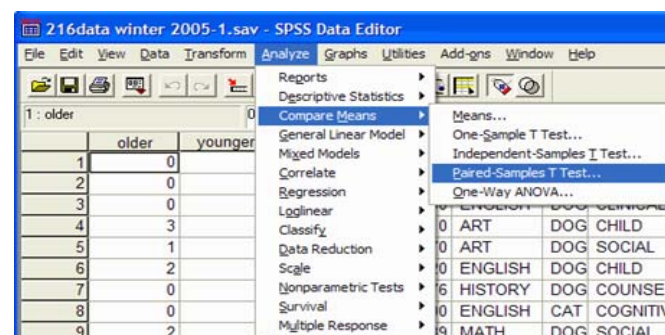

Figure 3 Independent t-test

Figure 4: Paired t-test sample example

One-way analysis of variance:

This is similar to a t-test. It is used to compare the mean score for the continuous variable for more than two groups. It has been given the name one way because it considers only the impact of one independent variable. A one-way analysis of variance (ANOVA) tells the discrimination amongst groups, but does not say anything significantly. ANOVA test has two types which are similar to t-tests as described above. The following is the procedure to calculate ANOVA using SPSS.

Procedure for one-way between groups ANOVA:

1. Select **Analyse** from the menu, click on **Compare Means,** followed by **One-way ANOVA**.

2. Select dependent (continuous) variable. Transport this to the box named **Dependent List** by clicking on the arrow button.

3. Select independent, categorical variable. Transport it in the box labeled **Factor**.

4. Select the **Options** button and click on **Descriptive**, **Homogeneity of variance test**, **Brown-Forsythe**, **Welch,** and **Means Plot**.

5. Missing values of data are represented by a dot. After that check, exclude case analysis for Missing values. Click on Continue.

6. Select the button **Post Hoc**. Select **Tukey**.

7. Select **Continue** and **OK.**

Procedure for one-way between-groups ANOVA:

1. Select **Analyse** from the menu, click on **Compare Means** and **One-way ANOVA**.

2. Select dependent (continuous) variable. Select the arrow to move this variable into the box marked **Dependent List**.

3. Select independent, categorical variable. Transport it to the box labeled **Factor**.

4. Select the **Options** button and select **Descriptive**, **Homogeneity-of-Variance,** and **Means Plot**.

5. Missing values of data are represented by a dot. After that check, exclude case analysis by analysis for missing values. Click on Continue.

6. Select **Contrasts** button. In the **Coefficients** box, type the coefficient for the first group. Click on **Add**. Repeat the same for the second and third group. The **Coefficient Total** at the end of the table should be equal to zero, if the data is entered correctly.

7. Select **Continue** followed by **OK.**

Procedure for computing one-way repeated measures ANOVA using SPSS:

1. Select **Analyse** from menu, followed by **General Linear Model** and **Repeated Measures**.

2. Type an independent variable name in the **Within-Subject Factor Name** box. This will label the independent variable.

3. Select **Number of Levels** box and input the number of levels involved.

4. Select **Add followed** by **define** button.

5. Select the three variables to represent repeated measures. Using the arrow button, transport variables into the **Within-Subjects Variables** box.

6. Select **Options** box.

7. Check **Descriptive Statistics** and **Estimates of effect size** boxes in the area labeled **Display**. For posthoc tests, click on the independent variable name in the **Factor and Factor Interactions** section and transport it into the **Display Means for the** box. Select **Compare main effects**. From the **Confidence interval adjustment** section, select the down arrow and choose the second option **Bonferroni**.

8. Select **Continue** and **OK**.

Two-way analysis of variance:

This analysis sees the impact of two independent variables on one dependent variable. It has the advantage of measuring the effect of one independent variable under the influence of the other. It also has two types: 1) between groups ANOVA: this is used when the groups are different. 2). Repeated measures ANOVA: In this same group of people are tested but at different instance of time.

For more information, the following sources are given for further readings.

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