Personalize Systems for Psychological Evaluation Performance and Vigilance Monitoring

Marek Penhaker, Radka Jeziorska
Department of Cybernetics and Biomedical Engineering,
VSB-Technical University of Ostrava, FEECS
Czech Republic
e-mail: marek.penhaker@vsb.cz, radka.jeziorska@vsb.cz

Vilem Novak, Katerina Panackova
Children Neurology Clinic
University Hospital Ostrava, Czech Republic
Czech Republic
e-mail:vilem.novak@fno.cz , katerina.panackova@vsb.cz

***Abstract* - This work deals with the monitoring of sleep deprivation, sleep disorders and investigative methods for their diagnosis. The aim of this work was to develop an algorithm for measuring and evaluating mental performance and vigilance tested. Computer based program consists of six tasks that tested memory, reaction time, coordination of movement and level of sleepiness using the Epworth Sleepiness Scale. Sixty measurements were performed using the above mentioned program. These data were statistically processed and characteristic values were determined for a select group of healthy people. For the creation of the program, the Visual C# development environment was used, and the measured data are stored in a MS Access database on cloud. Statistical data processing was done in software Statgraphics Plus.**

Keywords - sleep disorders diagnosis; Epworth scale; mental performance; vigilance; statistical evaluation.

I. INTRODUCTION

Sleep is a basic biological need. It is characterized by reduced movement activity and reduced reactivity to external influences. The body while it rests, function system slows down and starts running the regenerative processes. The changes in physiological changes, reduced body temperature, slowing of the heart and respiratory rate, reduced blood pressure, changing hormone levels in the brain. Good quality sleep is important for maintaining good physical and mental health. It is essential for the proper functioning of the central nervous system (CNS), assists in tissue regeneration and healing, promotes healthy growth, and restores the immune system and thereby increasing the body's resistance to disease.

Total sleep time per day for different animals differs greatly, approximately from 2 hours to 20 hours. The sleep duration for humans is individual. It is reported that the average sleep of humans lasts 7-8 hours, but some individuals have different sleep needs can vary from 4 to 12 hours of sleep per day. [1],[2]

A. Sleep Disorders

Studies show that 40% of adults have sleep problems and their number increases with increasing age. About 25% of adults indicates occasional sleep disorders, 10% are difficulties permanent and 5% of respondents suffer from excessive daytime sleepiness, and it influence work is social impact on their quality of lives. Under the current international qualification with sleep disorders divided into six basic categories: insomnia, respiratory disorders linked to sleep, hypersomnia, circadian rhythm disorders, parasomnias and abnormal movements linked to sleep.

B. Circadian Rhythm Disorders

Circadian rhythm disorders arise different timing of our own biological rhythm or the rhythm desynchronisation required external environment. Among these syndrome disorders include changes time zones (jet lag syndrome), which arises time shift during transcontinental flights. Other disorders related to circadian rhythm shift work. Daytime sleep for workers who perform night shift, fully substitute its length or quality night's sleep. In delayed sleep phase one goes to bed around 2 to 4 hours of the morning and getting up late in the morning until noon. Conversely, at advanced stages people go to bed early tonight (18 to 20 hours) and wakes up very early in the morning (1 to 3 hours).[3, 4]

C. Symptoms of Sleep Deprivation

Symptoms include emotional problems, anxiety, stress and depression, people are irritation. During prolonged insomnia may occur disorientation and problems with speech. These symptoms usually disappears after sufficient sleep and have no other consequences. Chronic insomnia can have long-term consequences, such as high blood pressure, heart failure, and psychiatric problems in the worst case, death.

D. Exploatation

Sleep deprivation is used in scientific studies to investigate the function sleep and its biological mechanisms. Most often used in laboratory rats, for which examines how total sleep deprivation and deprivation of REM or NREM only phase. Lack of sleep is also used as a torture and interrogation techniques. This fact is used tired that people are more likely to speak the truth. Investigation is the first kept awake for several days and then when he is finally allowed to fall asleep, suddenly awakened and interrogated. According to recent studies it is possible to use sleep deprivation, also for the treatment of depression. This stages have to be measured and analyzed especially for industry and medical application and safety maintenance. [5],[6],[7]

E. Examination Methods

The basic step for the diagnosis of sleep disorders is a detailed medical history specifying sleep and diet excluding exogenous factors (drugs, alcohol, drugs).This history some patients sufficient for a diagnosis. Character disorder specify sleep questionnaires, eg. sleep diary, Epworth sleepiness scale or Stafford sleepiness scale (ESS). Basic testing method is polysomnography. The differential diagnosis individual failures is used multiple sleep latency (MSLT) and maintain wakefulness test (MWT) which is determined using the measure of daytime

 ISBN: 978-1-61208-424-4

sleepiness. The independent self-monitoring system for sleep deprivation and vigilance is not common or the systems are under psychologists and neurologist's control in ambulance. [8],[9],[10],[11]

II. Measurement of Mental Performance and Vigilance

The aim of this work was to design and develop a methodology for testing and evaluation of mental performance and vigilance tested. Program was created consisting of six tasks which test memory, reaction time, coordination of movement and level of sleepiness using the Epworth Sleepiness Scale. The obtained data are stored in a database and will be further processed and analyzed statistically.

A. Database Conception

The database structure was designed so that the information it contained as much information on mental performance and alertness of the patient like time of the test each task, errors in tasks, number of success answer act. To connect to the database through a data adapter Microsoft.ACE.OLEDB.12.0, because the database was created in .accdb format (Microsoft Access). The database is located in the data directory of the program and mirroring to google Drive cloud. [12],[13],[14]

B. Task 1 - Presentation of Words and Their Immediate Equipment

The first task is focused on memory investigated. This task is not determined only number of correctly remembered words, but also the number of poorly remembered and words that said the test more than once. The monitor will gradually appear 30 words (Figure 1). The challenge is to remember what they most. When all the words have tested must equip as many words presented, Regardless of how the order. The memorized words then enter in the text box (Figure 1), which appears after presentation of all 30 words. The role is not limited. Presentation of words is repeated three times. For each repeating the same words appear in the same order as in the first experiment. It is necessary to always insert all remembered the words, including those that were already entered in previous experiments. That we will not only memorized the number of words in each experiment, we also observe whether repeatedly tested remember more words.

Figure 1.Inserting memorized words

C. Task 2 - Sorting Numerical Series

The objective of this task is to sort the numbers 1 to 15 in the fastest time. For this purpose form in which the 15 keys with individual numbers (Figure 2), these buttons are arranged in three rows and five columns. Button sequence is random. When you click on this button right. The button will disappear. This task is not recorded only time during which the test line up correctly series of numbers, but also the number of false clicks.

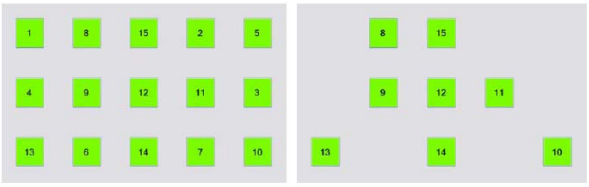

Figure 2. Sorting numerical series

D. Task 3 - Test of the ReactionTtime

This role is based on a psychomotor vigilance test, the test responds pressing the button to light the bulb. In my role appear on the monitor green rectangle, which will be at different time intervals to change color to red (Figure 3). The goalies to click on the rectangle as soon as possible after the color change from green to red. The color varies randomly in the interval 2-10 seconds. Total time jobs are 2 minutes. Do database imposing reaction time individual experiments from which the end of the job calculated average reaction time. An important figure is the number of false clicks, ie. clicks, when the rectangle green.

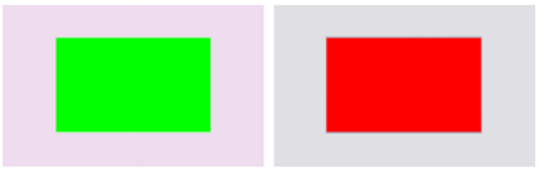

Figure 3.Change the color of the rectangle

E. Task 4 and 5 - Pulling Shapes

These tasks are focused on the coordination of movement. The monitor shows the image Star shaped (Figure 4). The challenge is to shape Stroke clockwise, move the mouse but is reversed - up is down and down is up, left and right direction remains unchanged. Properly trace shape changes color. If you get out of shape, color cursor turns red and must be returned to the place buckling. The task starts ramming of blue point and ends when the entire pattern correctly trace or after 90 seconds. Results in displacement, which trace the test, expressed in percentage. This task is carried out first and then the dominant non-dominant hand

F. Task 6 - Epthword Sleepiness Scale

This questionnaire (Figure 5) measures the general level of sleepiness during the day. Identifies option snap or sleep on a 4-point scale (0 - I'd never take a nap/a, 1 - a small chance nap, 2 - medium chance nap, 3 - high chance nap) in 8 different situations or activities that are part of everyday life. The total score is the sum of ESS points in different situations and can take values from 0 to 24. The database is not saved only the total score, but also the results for each scenario. The results of this task will be taken as a reference in statistical data processing

 ISBN: 978-1-61208-424-4

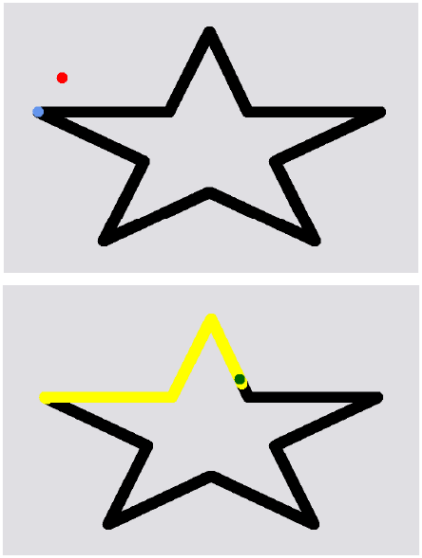

Figure 4. Pulling shapes

III. PROGRAM CONTROL

Program Control for measuring mental performance and alertness is done by tablet or mouse. It was necessary to find a tool that would enable the program to operate even if one not used to working with a mouse. These people could be misrepresented the results of each task. [15],[16]

Tablet was chosen as a compromise between control mouse and implementation of special control. It consists of a solid substrate with an active area of a rectangle and moving the sensing device in the form of a wireless pen. The computer input peripherals allows operate a computer in a similar way as a computer mouse (cursor control).

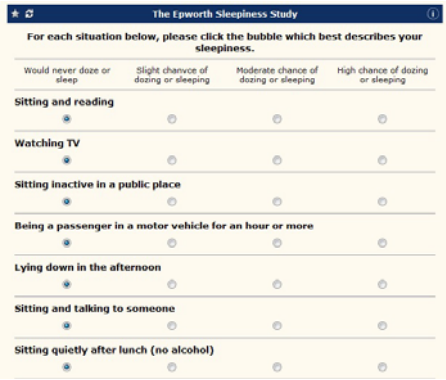

Figure 5.Epworth Sleepiness Scale

To realize the test was elected tablet G-Pen F610 (Figure 6). It is a widescreen tablet with a working area of 150 x 250 mm (6 x 10 „). The computer is connected via an interface USB, from which is also supplied. For their work with the tablet used pressure-sensitive pen, which is capable of recognize the 1024-level pressure for accurate shooting. The pen is cordless and are available there dedicated buttons for left and right mouse button.

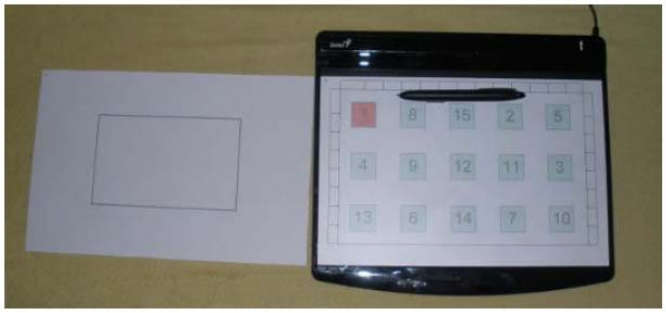

Figure 6. Tablet templates for test

When testing must be used in tablet mode, absolute positioning, the position of the pen on the tablet corresponds to the position of the cursor on the screen. This is adapted to the program, which individual form elements adapt to the screen resolution, and therefore can be used monitors of different sizes and different resolutions. For the role of „Sorting numerical sequence“ and „Test reaction time“ were then created templates (Figure 6), which help better control tasks using a tablet. These templates are inserted top sheet tablet. [17]

IV. STATISTICAL EVALUATION OF MEASUREMENT DATA

Data were obtained using an assay for measuring mental performance and vigilance. Was tested a total of 60 people aged 21 to 28 years. Tested had normal sleep patterns and not been treated with any kind of sleep disorder. The statistical evaluation was used program Statgraphics Plus version 5.0.

A. Analyzed data

Output data in a program objectively measured data showing mental performance and alertness measured entity. These data are classified using variables which serve as input for statistical evaluation.

The same number of men (n=30) and women (n=30) took part in the measurement. Number of tested with dominant right hand is n=51 what creates 85% of all respondents. Number of tasted with dominant left hand is n=9 what creates 15% of all respondents.

The examined group of persons that was selected for this study is the group of young people of age between 20 to 30 years who, in time of the testing, did not suffer from any hypnophrenosis and who had normal sleep habits. 60 respondents of the age from 21 to 28 years complied with this criterion from which there were 30 men and 30 women. Before the intrinsic test completing the tested were asked not to use any drinks with caffeine content, e.g. tea or coffee, and also not to smoke.

Time demand on the test gave rise to the creation of two versions because its length ranges approximately from 20 up to 30 minutes. Therefore, a part of data was collected by means of the first version when the tablet was used for controlling. The rest of data was obtained from the respondents to whom the program was sent by e-mail. The advantage of this version was addressing of a huge number of persons. The response rate was about 50% in this case. [17]

 ISBN: 978-1-61208-424-4

V. RESULTS

A. The Dependence Between the Total Score and the ESS Sex

The first step of the test according to the total score of the ESS and sex create a Table (Tab. 1), which contains the observed frequency and the relative frequency and the expected frequency. For proper results it is necessary to observe the test assumption that none of the expected frequency of not less than 2 and at least 80% of the expected frequency must be greater than 5. To meet these prerequisites are met, the overall score ESS divided into three categories: 0-6 points, 7-8 points, and 9-24 points.

TABLE I. A FREQUENCY TABLE FOR THE CORRELATION BETWEEN THE TOTAL SCORE AND ESS

	1-6 standart value	***7-8 border value***	***9-24 increased value***
man	14 23,33% 14	7 11,67% 7	9 15,00% 9
woman	14 23,33% 14	7 11,67% 7	9 15,00% 9
Sum	28 46,67%	14 23,33%	18 30,00%

On Table (Tab. 1) is seen that all of the expected frequency of greater than 5, it is possible to use the chi-square test. Before the test still possible the null and alternative hypotheses:

- The null hypothesis is: ESS depend on gender.
- The alternative hypothesis is: ESS depends on sex.

Since the p-value was set to 1, i.e., p-value is greater than 0.05, do not reject the null hypothesis and we can say that the overall ESS scores depend on the sex (of at level 0.05).

B. Correlation Between the Number of Memorized Words and a Total Score of ESS

In this test, we find that the correlation between the number of memorized words on the third attempt and a total score of ESS. ESS scores are divided into three groups of 0-6 points 7-8 points 9-24 points. To determine this dependence, we use ANOVA method by which we can compare the mean number of selections. Must be met assuming a normal distribution and homoscedasticity (ie. The same variance). If you have the same scattering data, but does not come from a normal distribution, we used the nonparametric Kruskal-Wallis test, the mean values do not test, but compliance medians.

First, we formulate null and alternative hypotheses:

- Null hypothesis: Number of memorized words depend on the ESS score.
- Alternative hypothesis: Number of memorized words depends on the ESS score.

Before the test is needed to verify the normality of the data, where the null hypothesis is: The data comes from a normal distribution. For testing normality is used chi-square test of goodness of fit. P-value of 0.031 is the first choice, ie. p-value <0.05, so we reject the null hypothesis and we can say that the data come from a normal distribution. P-value for the second selection is 0.208, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution. P-value 0.343 is the third selection, ie. p-value> 0.05, therefore, we accept the null hypothesis and we can say that the data comes from a normal distribution.

Next, we verify homoscedasticity, where the null hypothesis is: Scattering of memorized words all selections are the same. Because the data from the first choice does not come from a normal distribution, use Levene test. P-value is 0.10, ie. p-value> 0.05, do not reject the null hypothesis and we can say that the spread of memorized words all selections are the same.

Because the data from the first choice does not come from a normal distribution, we cannot use ANOVA. To test the dependence use Kruskal-Wallis one-way analysis of variance to test conformity medians. P-value of 0.018. This value is smaller than the significance level of 0.05, so we reject. Analysis of sleep deprivation null hypothesis and accept the alternative hypothesis. We can say that the number of memorized words depends on the total score (ESS at a significance level of 0.05).

For a more accurate conclusion in rejecting the null hypothesis needs to be done post hoc analysis. The maximum number of memorized words are tested with a lower Scores for ESS. The biggest difference in the number of memorized words is tested with ESS between 0-6 and 7 to 8 more homogeneous than the time required to sort the numerical range for the test with ESS 7-8 and ESS 9 to 24 The higher the ESS, the longer the time required to sort the numerical series. The biggest difference time required to sort the numerical series is among tested with ESS 0-6 and 9 to 24

C. Dependence Between the Average Response Time and Overall Score ESS

In this assay, verify whether the relationship between the reaction time and the average total score of the ESS. ESS scores are divided into three groups of 0-6 points 7-8 points 9-24 points. To determine this dependence, we use ANOVA method by which we can compare the mean number of selections. Must be met assuming a normal distribution and homoscedasticity (ie. The same variance). If you have the same scattering data, but does not come from a normal distribution, we used the nonparametric Kruskal-Wallis test, the mean values do not test, but compliance medians.

First, we formulate null and alternative hypotheses:

- Null hypothesis: The average response time does not depend on the total score of ESS.
- Alternative hypothesis: The average response time depends on the total score of ESS.

Before the test is needed to verify the normality of the data, where the null hypothesis is: The data comes from a normal distribution. For testing normality is used chi-square test of goodness of fit. P-value of 0.67 is the first choice, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution. P-value is 0.15 second selection, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution. P-value of the third selection is 0.45, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution.

 ISBN: 978-1-61208-424-4

Next, we verify homoscedasticity, where the null hypothesis is: Scattering average times of all selections is the same. Because all selections are normally distributed data, use Bartlett's test. P-value is 0.056, ie. p-value> 0.05, do not reject the null hypothesis and we can say that the variance of the average reaction time of selection is the same.

Because all the preconditions are met, we can proceed to the actual ANOVA. P-value is 0.0002. This value is smaller than the significance level of 0.05, so we reject the null hypothesis and we can say that the average response time is dependent on the overall score ESS (at a significance level of 0.05).

D. Dependence Between the Track Trace Non-Dominant Hand and aTotal Score of ESS

In this test, we find that the relationship between the track non-dominant hand and an overall score of ESS. ESS scores are divided into three groups of 0-6 points 7-8 points 9-24 points. To determine this dependence, we use ANOVA method by which we can compare the mean number of selections. Must be met assuming a normal distribution and homoscedasticity (ie. The same variance). If you have the same scattering data, but does not come from a normal distribution, we used the nonparametric Kruskal-Wallis test, the mean values do not test, but compliance medians.

First, we formulate null and alternative hypotheses:

- Null hypothesis: The track does not depend on the total score of ESS.
- Alternative hypothesis: The path depends on the total score of ESS.

Before the test is needed to verify the normality of the data, where the null hypothesis is: The data comes from a normal distribution. For testing normality is used chi-square test of goodness of fit. P-value of 0.0001 is the first choice, ie. p-value <0.05, therefore rejected the null hypothesis and I can say that the data come from a normal distribution. P-value of 0.071 is the second choice, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution. P-value 0.343 is the third selection, ie. p-value> 0.05, so do not reject the null hypothesis and we can say that the data comes from a normal distribution.

Next, we verify homoscedasticity, where the null hypothesis is: Scattering tracks all selections are the same. Since the date of first choice does not come from a normal distribution, use Levene test. P-value is 0.59, ie. p-value> 0.05, do not reject the null hypothesis and we can say that the scattering paths all selections are the same.

Because the data from the first choice does not come from a normal distribution, we cannot use ANOVA. To test the dependence use Kruskal-Wallis one-way analysis of variance to test conformity medians. P-value is 0.16. This value is greater than the significance level of 0.05, so do not reject the null hypothesis. We can say that the track trace non-dominant hand is independent of the total score (ESS at a significance level of 0.05).

VI. DISCUSSIONS

The aim of this work was to study methods for the diagnosis of sleep disorders and the creation of a program to measure mental performance and alertness on the basis of which it is possible to determine whether the test suffers from lack of sleep. Was designed and created program stack the six tasks with which testing memory, reaction time, coordinate the movement and level of sleepiness.

There were an average of individual tasks for testing in the range 21 to 28 years who have normal sleep patterns and do not suffer from a sleep disorder. The first task was tested by memory. The average number of words memorized in the first experiment was 10.1 ± 3.1 words, in the second experiment, it was 16.2 ± 3.8 words, in the third 21.0 ± 3.5 words. In the second task was average time required to sort the numerical series 13.8 ± 2.4 seconds. The average reaction time in the third test role was 0.438 ± 0.067 seconds. Percentage tracks trace dominant hand was 70.7% ± 22.5%, when using non-dominant hand, the percentage of paths 69.3% ± 26.0%. The value of total Epworth Sleepiness Scale score was 7.1 ± 3.2.

As a point of reference was chosen Epworth sleepiness scale, the results of which were compared results of the study Dr. Murray Johns, who created this method. Because the results of ESS in this study were comparable to studies, it was possible to use the results for further testing.

In testing, it was found that there is a correlation between the number of memorized words, the time required for alignment of numerical series and the average reaction time and the total score of the ESS. At the same tim the followed track traced of both dominant and non-dominant hand depends on the overall ESS score is strongly.

VII. CONCLUSIONS

Computer aided testing of psychometric variables seems to be very useful in the medical practice and research. Many testing procedures are well-grounded by a simple algorithm and they are suitable for the implementation in a form of the computer software. The software enables a quick and cheap measurement of the psychometric variables.

The effect of the personal UI interaction within device is conclusive for accuracy and reliability of the psychometric evaluation. The classical PC's UI are not very appropriate because of variable computer skills in population. The button device as used in the Cognitive Drug Research Ltd. System is more useful due to its simplicity. Use of pressure-sensed pen and tablet is another interesting way because of almost general writing skills in population.

This method of measuring mental performance and alertness was created in collaboration with the University Hospital in Ostrava. The proposed scheme can be further used for testing and collection of additional data and to determine the average value, characterizing the other groups tested.

ACKNOWLEDGMENT

The work and the contributions were supported by the project SP2015/179 'Biomedical engineering Systems XI', and this paper has been elaborated in the framework of the project „Support research and development in the Moravian-Silesian Region 2014 DT 1 - Research Teams“(RRC/07/2014). Financed from the budget of the Moravian-Silesian Region.

 ISBN: 978-1-61208-424-4

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