Computer Based Psychometric Testing and Well Being Software for Sleep Deprivation Analysis

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Abstract. In clinical practice we often utilize measurements of psychic functions that help to determine diagnosis, disease stage but also favourable or unfavourable influences of the treatment. So called gnostic and executive psychic functions are important for the quality of life. The process of computer aided evaluation of the psychic functions is valuable especially from the reason of its acceleration and reduction in price. Higher degree of standardization seems to be another benefit of the computer aided evaluation. Within cooperation between the University Hospital Ostrava and the VSB Technical University of Ostrava we have developed software for measurement of the psychometric variables. A part of the research is also standardization of the results by a method of pilot testing within a group of healthy volunteers.

Keywords: Psychometric measurements, cognitive function, sleep laboratory, video-EEG, and software.

1 Introduction

Evaluation of the psychic functions, e.g. the gnostic functions that include selection, maintenance, classification and integration of information, learning and speech [1,2] is a part of the clinical examination in the neurology. The psychometric examination is often utilised within the medical clinical research. In the past, the testing was executed by means of various questionnaires and forms. Their processing was time-consuming. Software for the psychometric measurement accelerates the examination process and reduces its time and price and it gives also more precise results.

The following psychometric variables are measured routinely:

Attention:
- Simple reaction time
- Choice reaction time

Memory:
- Recent memory
- Long-term memory

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Speech functions:
Vocabulary and fluency
Praxis and motorcoordination:
Space memory, figures
Test of figure tracing (dominant and subdominant hand)
Complex functions
Digit symbol substitution test
Vigilance:
Epworth sleepiness scale

Changes of these functions are important indications of diseases as e.g. Alzheimer's disease [3], Parkinson's disease or sleep disorders. However, they might be also influenced by applied medicinal drugs. Most types of drugs affecting the central nervous system and many others such as antihistaminergic agents produce impairment in human cognitive functions [4]. Sleep disturbances and their impact to cognitive functions is another field for psychometric testing.

Psychometric measurements are therefore frequently used in clinical trials with new pharmaceutic agents to monitor their cognitive effects.

There are many computer-based systems measuring the psychic performance of the patient used both in clinical and research settings. One of the most sofisticated systems is the software product of the Cognitive Drug Research Ltd. (CDR) now as a part of the United BioSource Corporation. The system is being developped since 1970s and has more than 50 possible sub-tests localized to most languages. It is composed from a series of brief neuropsychological tests (batteries). Most of the tests are brief in duration (1 to 3 minutes). The computer keyboard is not used in any test. Many responses are made via USB device with YES and NO buttons [4]. The CDR system has become a standard in testing the cognitive effects in pharmaceutical research.

In general, the effect of the interface between computer and patient (buttons device, tablet, mouse, keyboard) is crucial for the accuracy, because of inequal computer skills in different persons.

2 Study Aim

Within the biomedical research programme of two cooperating institutions, a new application for the psychometric measurements was developed. The aim was to develop software performing various psychometric tests. The software might be utilised on PCs as well as on other types of hardware as tablets or smart mobile phones. Another aim was the standardization of tests' results that come from the computer aided testing of a group of healthy volunteers of selected age groups.

The integration of some testing modules to the video-EEG system with a possibility of attention deficit disorders detection and its correlation with epileptiform activity in EEG is recording as the next step.

3 Technical Specification

3.1 Development Environment

The program was created in C# language with utilisation of the development environment of Microsoft Visual C# 2008 Express Edition. This environment is used to develop console applications and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both machine code and managed code for all platforms supported by Microsoft Windows, Windows Mobile, and for some more supported platforms. The built-in tools include a forms designer for building GUI applications, web designer, class designer, and database schema designer. Data are saved to MS Access database by means of ODBC interface.

3.2 Controling the Software

During the psychometric software development we had to solve the problem of various levels in skill to work with a computer mouse. Ability to use the computer mouse might significantly distort inter-individual comparability of the results of some tasks.

Therefore the tablet was selected as a compromise between the mouse control and realisation of a special control element. It consists of a fixed pad with the active rectangular area and from a moving sensing device in a form of the wireless pen. This computer input periphery enables controlling the computer by a similar way as the computer mouse (cursor control).

3.3 Tablet G-Pen F610

The tablet G-Pen F610 was selected for the testing (Pict. 12). It deals with a widescreen tablet that disposes of 150 x 250 mm (6 x 10") working area. It is connected to a computer by means of USB interface from which it is also supplied. For the intrinsic work with the tablet a pressure-sensed pen serves that can distinguish 1024 levels of the pressure for precise sensing. The pen is wireless and disposes of special push buttons that serve as the right and left mouse keys.

When the tablet is used for the testing, the mode of absolute positioning when the pen position on the tablet corresponds to the cursor position on the screen is necessary. The software is also adapted to that mode. Individual elements of the forms can adapt to the screen resolution and therefore screens of various dimensions and of various resolutions might be used.

For the tasks of „Numeral Row Alignment“ and „Test of Reaction Time“ templates were created (Fig. 2) that enable better control of the tasks by tablet. These templates are inserted under the upper foil of the tablet.

Fig. 1. Tablet G-Pen F610

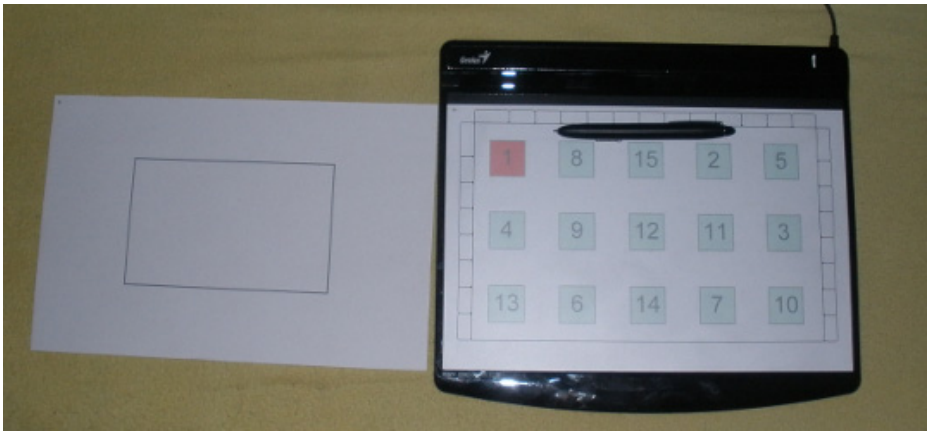

Fig. 2. Tablet and Templates for Test

4 Implemented Tests

4.1 Memory Recall Test

Thirty words are gradually displayed on the screen to the tested subject. The task is to recall as many words as possible, when their order is not important. The words recall might be tested immediately after their presentation (early recall) as well as later (delayed recall). Numbers of correct and incorrect answers are recorded.

4.2 Numeral Row Alignment

This task is to order numbers from 1 up to 15 as quickly as possible by clicking it. A form for this task contains 15 keys with the individual numbers (Fig. 3). These keys

are arranged in three rows and five columns and their order is random. After clicking on the correct key it disappears. Not only time, in which the respondent arranges the numeral row in correct order, but also number of incorrect answers/clicks is recorded. This test is to be performed on the tablet.

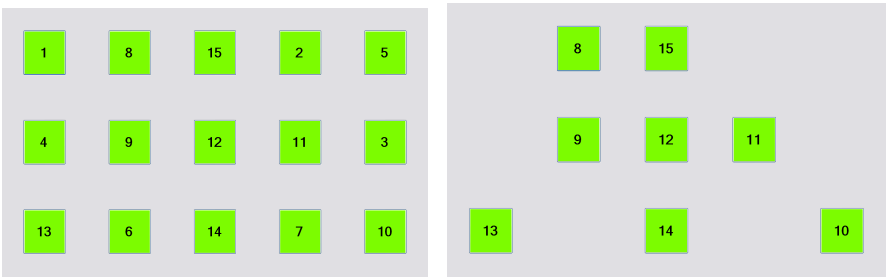

Fig. 3. Ordering of Numeral Row

4.3 Measurement of Simple Reaction Time

This task comes from the psychomotor tests of wakefulness when the respondent reacts by pushing a key when a bulb is switched on. In our implementation a green rectangle appears on the monitor that changes its colour to red in random time intervals (Fig. 4). The tested subject has to click as quickly as possible after the colour was changed from green to red. The colour changes haphazardly within the interval from 2 up to 10 seconds. The total time of this task is 2 minutes. Reaction times are saved in the database. When the task is ended, an average reaction time is calculated. A number of incorrect clicks, i.e. a click when the rectangle is green, is also an important piece of information.

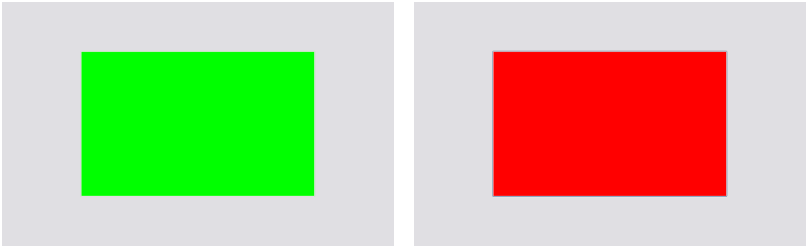

Fig. 4. Measurement of Simple Reaction Time

4.4 Figure Tracing

The task is focused on space orientation and movement coordination. There is a figure in the shape of a star on the screen (Fig. 5). The task is to trace the shape in clockwise direction. The task is complicated by the fact that cursor reaction does not comply

with the mouse movement in upwards and downwards direction while the cursor reaction complies with the mouse movement in leftwards and rightwards direction.

The shape traced correctly changes the colour. If the examined person gets off the figure while tracing, the cursor changes its colour to red and it is necessary to return to the point where it got off. The monitored value is a trajectory that is traced by the respondent correctly. It is stated in percent.

At first, the figure tracing is made by the dominant hand and for the second time by non-dominant hand.

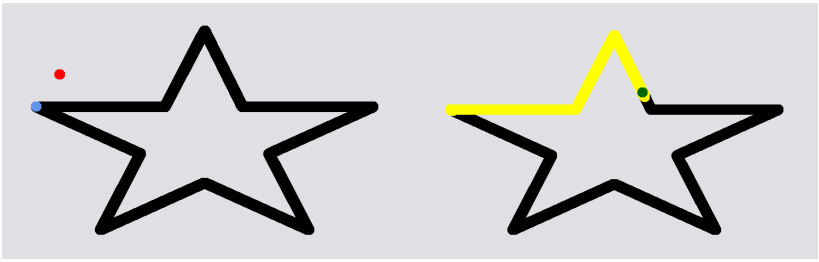

Fig. 5. Figure Tracing Test

4.5 Epworth Sleepiness Scale

It is a simple questionnaire for adults' sleepiness measurement. The patient self-evaluates his/her tendency for falling asleep on a scale of 4 grades (from 0 up to 3 points) in 8 common daily situations. The sum of points might range from 0 up to 24 while 10 points and less are considered the normal value, 11 points and more give evidence of excessive daily sleepiness. The software offers electronic implementation of this widely used questionnaire [4,5].

5 Standardization of Tests

The psychometric tests were applied on a group of healthy volunteers. The results of this pilot statistic processing are presented here.

5.1 Description of Volunteers' Sample

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 testees with dominant left hand is n=9 what creates 15% of all respondents

The testing was perfomed since the 15th March to 4th April 2011. In total, 65 persons took part in the testing. Their age ranged from 21 to 62 years from which 34 men and 31 women created the sample.

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.

Two versions of the program were created for the testing in order that we obtained the same parameters. The first version of the program needs assistance of a person testing for the task 1 – Words presentation and their consequent recall. The tested subject does not write the recalled words to the database himself/herself but the person testing can see a list of all the words after their presentation and ticks correct words in the list that the tested gradually recalls. The advantage for this version is that numbers of words are directly saved to the database for the individual attempts. The second version does not require assistance of the person testing because the examined person writes the recalled words directly to the database. The action of the person testing is not necessary earlier than at results evaluation when the presented words must be compared manually with the recalled words.

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.

5.2 Results Assessment

Sixty five persons of age from 21 to 62 years took part in the testing. From the point of view of the statistical analysis, the respondents aged between 20 to 30 years were selected. It dealt with 60 tested from whom there were 30 men and 30 women aged from 21 to 28 years with the average value 24.1 ± 1.77 years. A number of the tested with dominant right hand was 51 (85%), a number of the tested with dominant left hand was 9 (15%).

5.3 Memory Recall Test

Within the first attempt from 4 to 17 correct words were recalled with the average value 10.1 ± 3.1 words. From the total number of 60 tested, 44 respondents did not have any wrong word and 45 respondents had maximally 1 duplicate word. Within the second attempt from 7 to 23 correct words were recalled with the average value 16.2 ± 3.8 words. From the total number of 60 tested, 54 respondents did not have any wrong word and 31 respondents had maximally 1 duplicate word. Within the third attempt from 14 to 28 correct words were recalled with the average value 21.0 ± 3.5 words. From the total number of 60 tested, 43 respondents did not have any wrong word and 34 respondents had maximally 1 duplicate word.

5.4 Ordering of Numeral Row

For the second task, the time necessary for ordering of the numeral row ranged from 8.7 to 22.4 seconds. There were some distant measurements caused by excellent skill in work with the mouse in the area of best times and on the contrary the worst times were the cause of insufficient skill in the tablet control. The average time was 13.8 ± 2.4 seconds. A number of wrong clicks ranged from 0 to 3 mistakes when 41 respondents coped with the task without a mistake.

5.5 Simple Reaction Time

Within the third task, the average simple reaction time moved in the range from 0.315 – 0.684 seconds. Two distant measurements occurred here that were the cause of insufficient skill in the tablet control. The average reaction time was 0.438 ± 0.067 seconds. A number of wrong clicks ranged from 0 to 4 mistakes when 40 respondents coped with the task without a mistake. Interesting question for a new measurement and psychological consideration that came out is the relationship between the colour and shape of the signal figures and the reaction time.

5.6 Figure Tracing

A range of the traced trajectory by dominant hand moved from 34% to 100% when the average trajectory was 70.7% ± 22.5%. A range of the traced trajectory by subdominant hand moved from 12% to 100% when the average trajectory was 69.3% ± 26.0%. When the relation between the trajectory length traced by dominant and subdominant hand was evaluated, it was found out that the difference between the dominant and subdominant hand is not statistically significant. This is surprising, because in general the non-dominant hand should be more successful in this type of test (we should perform more testing of this point).

5.7 Epworth Sleepiness Scale

The last task determinated the sleepiness level by means of the Epworth sleepiness scale [5, 6]. Within our study this method is considered as the reference one because its results might be compared with some studies that dealt with this topic. The total score range was from 1 to 16 with the average value 7.1 ± 3.2. One distant measurement was discovered which means that the tested subject probably suffers from hypersomnia.

6 Conclusion

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 subject-person/computer interface device is crucial for accuracy and reliability of the psychometric measurement. Keyboard and mouse is not very appropriate because of variable computer skills in population. The button device as used in the CDR 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.

In the future, we plan continual measurements of some psychometric parameters as e.g. the reaction time and its integration to video-EEG signal in a form of a polygraphic channel. The psychometric tests are important not only for the clinical practice but they also offer possibilities for some student within training of the programming and mathematic statistics at the Technical University.

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References

1. Boller, F., Grafman, J. (eds.): Handbook of Neuropsychology, vols. 1-11. Elsevier, Amsterdam (1988/1997)
2. Ardila, A.: Houston Conference: Need for More Fundamental Knowledge in Neuropsychology. Neuropsychology Review 12(3) (September 2002)
3. Lewis, L., Mahieux, F., Onen, F., Berr, C., Volteau, et al.: Early Detection of Patients in the Pre Demented Stage of Alzheimers Disease; The Pre-Al Study. The Journal of Nutrition, Health & Aging 13(1), 21 (2009)
4. Wesnes, K.A.: The value of assessing cognitive function in drug development. Dialogues Clin. Neurosci. 2(3), 183–202 (2000)
5. Johns, M.W.: A new method for measuring sleepiness: the Epworth sleepiness scale. Sleep 14, 540–545 (1991)
6. Epworthsleepinessscale.com, The Epworth sleepiness scale (2010), `http://epworthsleepinessscale.com/` (cit. January 02, 2011)
7. Havlík, J., Dvořák, J., Parák, J., Lhotská, L.: Monitoring of Physiological Signs Using Telemonitoring System. In: Böhm, C., Khuri, S., Lhotská, L., Pisanti, N. (eds.) ITBAM 2011. LNCS, vol. 6865, pp. 66–67. Springer, Heidelberg (2011)
8. Hudak, R., Michalikova, M., Toth, T., Hutnikova, L., Zivcak, J.: Basics of bionics and biomechanics: an e-learning course on the ulern platform. Lékař a Technika 36(2), 209–213 (2006) ISSN 0301-5491

9. Kasik, V.: Acceleration of Backtracking Algorithm with FPGA. In: 2010 International Conference on Applied Electronics, Pilsen, Czech Republic, pp. 149–152 (2010) ISBN 978-80-7043-865-7, ISSN 1803-7232
10. Cerny, M.: Movement Monitoring in the HomeCare System. In: Dössel, O., Schlegel, W.C. (eds.) WC 2009. IFMBE Proceedings, vol. 25/V, pp. 356–357. Springer, Heidelberg (2009)
11. Krejcar, O., Jirka, J., Janckulik, D.: Use of Mobile Phone as Intelligent Sensor for Sound Input Analysis and Sleep State Detection. Sensors 11(6), 6037–6055 (2011), doi:10.3390/s110606037, ISSN: 1424-8220
12. Krejcar, O.: Human Computer Interface for Handicapped People Using Virtual Keyboard by Head Motion Detection. In: Katarzyniak, R., Chiu, T.-F., Hong, C.-F., Nguyen, N.T. (eds.) Semantic Methods for Knowledge Management and Communication. SCI, vol. 381, pp. 289–300. Springer, Heidelberg (2011)
13. Katarzyniak, R.P., Chiu, T.-F., Hong, C.-F., Nguyen, N.-T. (eds.): Springer, Heidelberg, doi:10.1007/978-3-642-23418-7_25, ISBN 978-3-642-23417-0, ISSN 1860-949X
14. Krejcar, O., Motalova, L.: Home Care Web Services Evaluation by Stress Testing. In: Yonazi, J.J., Sedoyeka, E., Ariwa, E., El-Qawasmeh, E. (eds.) ICeND 2011, Part 16. CCIS, vol. 171, pp. 238–248. Springer, Heidelberg (2011)
15. Brida, P., Machaj, J., Benikovsky, J., Duha, J.: An ExperimentalEvaluation of AGA Algorithm for RSS Positioning in GSM Networks. Elektronika Ir Elektrotechnika 104(8), 113–118 (2010) ISSN 1392-1215
16. Liou, C.-Y., Cheng, W.-C.: Manifold Construction by Local Neighborhood Preservation. In: Ishikawa, M., Doya, K., Miyamoto, H., Yamakawa, T. (eds.) ICONIP 2007, Part II. LNCS, vol. 4985, pp. 683–692. Springer, Heidelberg (2008)
17. Brad, R.: Satellite Image Enhancement by Controlled Statistical Differentiation. In: Innovations and Advances Techniques in systems, Computing Sciences and Software Engineering, International Conference on Systems, Computing Science and Software Engineering, December 03-12. Electr. Network, pp. 32–36 (2007)
18. Choroś, K.: Further Tests with Click, Block, and Heat Maps Applied to Website Evaluations. In: Jędrzejowicz, P., Nguyen, N.T., Hoang, K. (eds.) ICCCI 2011, Part II. LNCS, vol. 6923, pp. 415–424. Springer, Heidelberg (2011)