Influence of Properties of the Nervous System on Cognitive Abilities

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Abstract. The data analysis has demonstrated that the general intellect (IQ) has the high relationship with strength and functional mobility of nervous processes, if those indices have been strengthened indices proposed by authors (namely, accounting noise immunity indicators, as well as the verbal and nonverbal intellect) in the 1st group of subjects. Thinking ability had the higher relationship ($R = 0.80$, $p < 0.01$). At the same time, students-researchers (military psychophysiologists should be researchers) demonstrated much more close dependence in those indices: the general intellect had extremely high relationship with extended FMNP indices ($R = 0.82$, $p < 0.01$), and thinking ability even higher ($R = 0.95$, $p < 0.001$). The possible reasons and ways of application are discussed.

Keywords: Cognitive activity · Physiological support · External factors

1 Introduction

Though Industry 4.0 is still at a nascent and discussed phase, it is clear that technology will play a central role in nearly all aspects of our lives [1], and digital transformation is the most valuable trend and challenge, especially under effect of the Pandemic [2]. Digitalization of all human fields of activity has led to the emergence of new professions that needed high intellectual and creative abilities ensuring the high human professional performance [3]. Ability and readiness to learning and research activity became an important challenge to workforce capabilities [4] to meet requirements of the job market [5].

H. Ayaz et al. (Eds.): AHFE 2021, LNNS 259, pp. 114–119, 2021.
https://doi.org/10.1007/978-3-030-80285-1_14

At present, cognitive abilities predetermine the value of a person, both as a student and as an employee, and the talent hunting and talent management are important tools at the workforce market [6]. Measurement of the intelligent and emotional quotients are used very often, however not only the intellect, but also thinking ability and appropriate personality traits are needed for many professions [7].

Purpose. Analysis of relationship between intellect components, mindfulness, personality traits and features of the nervous system of experienced specialists and master students in occupations related to the cognitive work.

2 Method

The methodological basis of our research is a computerized technique based on models and methods for assessment of human abilities to cognitive work using intellectual and personality structures' indices for professional selection [8]. Tests were used as follows: modified R. Amthauer test of intellect structure; original and extended Hilchenko-Makarenko technique to measure strength (SN) and functional mobility (FMNP) of nervous processes; Myers-Briggs Type Indicator (MBTI).

The *tests* included:

Myers-Briggs Typology Indicator (MBTI); the purpose of use - an assessment of the ability to certain activities and individual properties of communication; Traditional indexes of an individual typology estimation according to the Myers-Briggs methodology are recorded based on the evaluation of the prevailing signs on the 4 criterion scales: extraversion E - introversion I (orientation of consciousness), intuition N - sensory S (way of orientation in a situation), thought/judgment J - perception P (method of preparation of decisions), thinking T - experience F (decision-making);

Modified Intellectual Structure Test for R. Amthauer (TCI); purpose of application - definition of the level of development and structural features of intelligence, as well as attention, memory; The following subtests are used (the brackets show the corresponding structural component of the intelligence): LS (testing of language, ability to formulate judgments), GE (conceptual intuitive thinking), AN (combinatorial abilities, mobility and ability to switch thinking), RA (ability to solve practical computational problems character), ZR (logical and mathematical thinking), FS (figurative synthesis), WU (spatial thinking), ME (memory, attention). The values of the structural components of intelligence were calculated as the sum of the correct answers for each subtest, the values of verbal (VI) and nonverbal (NI) intelligence - as sum of values, respectively, LS, GE, AN, ME and RA, ZR, FS, WU. The overall IQ score was calculated as the sum of values VI and NI with a correction factor of 1.462.

Hilchenko-Makarenko technique to measure strength (SN) and functional mobility (FMNP) of nervous processes. Individual-typological properties of higher nervous activity, due to the speed and mobility of nervous processes, are calculated [9].

The development was carried out in two main directions: first, the use of two consecutive 3-minute periods - without interference and with interference (in the form of color spots that appear randomly on the display screen, with simultaneous supply of sound signals of different modality); secondly, calculation not only of the minimum and final

reaction time, but also calculation of additional characteristics of dynamics of performance of the test; thirdly, determination of human interference immunity by calculating the ratio of the values of the same indicators when performing the test with and without interferences.

The following indicators were calculated (further in research and discussion they are marked with index "10"):

minT - the minimum time of presentation of the task, corresponds to the maximum rate of work of the person, his maximum working capacity; maximum work pace.

maxT - the maximum time of presentation of the task, at high productivity, as a rule maxT = To; minimum work pace.

To - the starting time of presentation of the task; starting work pace.

tmin - time to reach minT from the beginning of the test; time to reach maximum pace.

S - the speed of reaching minT, depends on both the individual and typological characteristics of man, the lability of his nervous system, and the ability to mobilize.

Tcp - the average work pace.

DminT = |minT – Tcp|, mobilization reserve.

DmaxT = maxT – Tcp, mobilization lost.

There were measured the same indicators when working with hindrances (marked with index "11"). Indicators of the interference immunity (as the ratio of the corresponding indicator of test 11 and test 10) were calculated: f_1 = Tcp11/Tcp10 - average interference immunity, f_2 = tmin11/tmin10 - interference immunity when reaching maximum performance's rate, f_3 = S11/S10 – interference immunity of the speed, and f_4 = minT11/minT10 - interference immunity at maximum performance.

The resulting primary data was entered into a spreadsheet for further analysis.

Subjects. 56 subjects participated in the research: 28 experienced medical care professionals (18–40 years old) and 28 Masters in Psychophysiology (Bachelor of Medicine, 21–23 years old).

3 Results and Discussion

As it has been demonstrated in our previous research, the relationship between physiological indices of adolescent and external factors (solar wind and atmospheric parameters) was medium, but significant [10].

Besides, the analysis of combined influence of the external factors (solar wind speed and density of its proton component at the time of test performance) and physiological maintenance has revealed their parameters' high correlation with tests performance speed, and especially reliability, in cognitive tests after selection of three the most informative independent variables in accordance with the standard procedure (standard package STATISTICA 6.0, a stepwise regression analysis).

The data analysis has demonstrated that the general intellect (IQ) had the high relationship with strength and functional mobility of nervous processes, if those indices have been strengthened indices proposed by authors (namely, accounting noise immunity indicators, as well as the verbal and nonverbal intellect) in the 1st group of subjects.

Thinking ability had the higher relationship ($R = 0.80$, $p < 0.01$). At the same time, students-researchers (military psychophysiologists should be researchers) demonstrated much more close dependence in those indices: the general intellect had high relationship with extended FMNP indices ($R = 0.82$, $p < 0.01$), and thinking ability even higher ($R = 0.95$, $p < 0.001$). The possible reasons and ways of application are discussed.

The analysis has been carried out in relation to dependence of the intellect (verbal VI and non-verbal NI components) on the features of the subjects' nerve system during cognitive activity.

The results of measurements demonstrated that partial coefficients of correlation were not very high (not higher than 0.6) for both VI and NI in both groups: medical care professionals (Fig. 1) and psychophysiologists-researchers (Fig. 2).

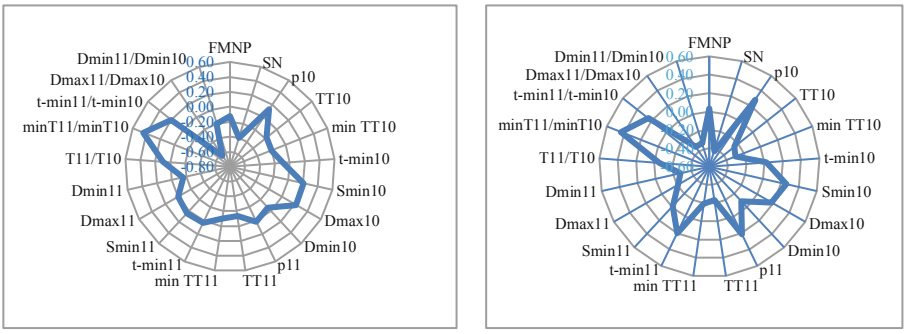

Fig. 1. Correlations histograms of the verbal (left) and non-verbal intellect (right) with features of the nervous system in cognitive test performance (medical care professionals)

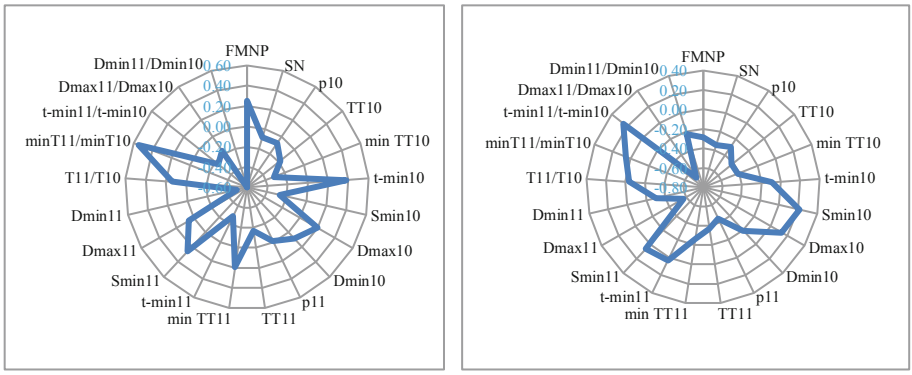

Fig. 2. Correlation histograms of the verbal (left) and non-verbal intellect (right) with features of the nervous system in cognitive test performance (psychophysiologists)

Low level of the relationship of FMNP and SN with the intellect has been revealed in both groups. At the same time, the highest relationship was demonstrated in both

groups in relation to maximum work pace ($r > 0, 4$), especially for the ratio of interference immunity f_4. Besides, psychophysiologists demonstrated higher relationship of the intellect with the performance rate.

To study if not alone indices of the nerve system of a human, but their joint impact could have high relationship with the intellect components, the further analysis was carried out: multiple correlation has been measured applying the forward stepwise analysis selecting three the most informative indices of the properties of higher nervous activity.

It has been revealed that the relationship for medical care professionals was above the medium level (VI: $r = 0.72, p < 0.01$; NI: $r = 0.63, p < 0.05$) and informative indices included ratio f_2, f_4 and SN. The relationship for psychophysiologists was higher (VI: $r = 0.79, p < 0.01$; NI: $r = 0.90, p < 0.01$) and informative indices were rate and reliability of the test performance.

As it is generally recognized, the intellect as a mental tool is not enough for the cognitive activity [11]. A way and type of thinking can play more significant role in practice [12]. To compare their relationship with the nerve system traits, we studied such a relationship between intuition and thinking features of subjects the same groups applying the same technique (the forward stepwise analysis selecting three the most informative indices), as it was described above.

It is necessary to highlight that relationship of general thinking ability was higher in the first group (medical care professionals) than in psychologists ($r = 0, 6$ and 0,4 accordingly). I.e., it is possible to make a decision that practical experience is more important in such type of cognitive tasks than features of the nerve system.

By selecting the 3 most informative independent variables according to the standard procedure, a stepwise regression analysis revealed: the coefficient of multiple correlation of the test intellect (index corresponds to the type of intellect) $R_{VI} = 0.7 \ldots 0.93$ ($p < 0.01$), $R_{NI} = 0.95 \ldots 0.97$ ($p < 0.001$).

4 Conclusion

The technique of studying the stability of cognitive abilities of high school students has revealed significant fluctuations in the speed and reliability of simple cognitive test tasks.

A strong correlation between subjects' cognitive test activity and individual properties of their cardiovascular and nervous system, as well as energy regulation and solar physiological parameters (speed and density of solar wind) has been revealed ($R = 0.88 \ldots 0.91, p < 0.01$).

Identified features of cognitive activity require further investigation and clarification of the mechanisms of regulation of such activity.

Acknowledgments. This research has been supported by the Institute of Information Technologies of the National Academy of Pedagogic Science.

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