Working Memory Test Efficacy Assessment in Patients with Asthenic Syndrome

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***Abstract*—In the current study, we analyzed the results of the cognitive test (Working memory task according to the Sternberg's paradigm) in patients with asthenic syndrome. To diagnose the severity and type of asthenia, we used the Multidimensional Inventory questionnaire (MFI-20). We propose a new performance metric that considers both the accuracy of the answers and their speed. Our findings demonstrate that individuals with more pronounced asthenic syndrome exhibit slightly higher efficiency in performing tasks related to working memory compared to those with less pronounced asthenia.**

***Index Terms*—asthenia, mental fatigue, cognitive task, working memory task**

I. Introduction

Asthenia is a psychopathological disorder, the symptoms of which include physical and/or mental fatigue with reduced activity (lack of vigor) and motivation (sadness), entailing clinically and socially significant consequences: the need for additional rest, a decrease in the volume and efficiency of work.As a result, such a painful condition can spoil the quality of life of a person. [1], [2]

The symptoms of asthenic disorder are diverse and strongly depend on the causes that caused asthenia, or the diseases against which it developed. Often such a syndrome accompanies the initial periods of most mental and somatic diseases of various etiologies. The relevance of studying the problems of asthenic disorders is determined primarily by their significant prevalence (as a rule, asthenic disorders occur in most somatic and psychosomatic diseases). In particular, WHO pays special attention to the connection of asthenic manifestations and COVID-19 [3], [4].

Thus, improving the methods of objective diagnosis of asthenic disorders with subsequent therapy will improve the compliance of treatment, shorten the rehabilitation period and, as a result, imrove the quality of the patient's life .

Currently, to determine fatigue there are subjective questionnaires (MFI-20, Fatigue Impact Scale [5], etc.), cognitive tests (Attention network Task [6], Eriksen Flanker Task (based on selective attention and executive control) [7], ,etc.) and objective methods based on physiological data (EEG [8]–[13], fNIRS [14], [15], EOG/Eye-tracking and ECG [16], [17], etc.). There may also be interest in fMRI diagnosis of depression [18]–[20], but these are more complex, labour-intensive and expensive than EEG and eye-tracking technologies. In this paper, we have attempted to objectively assess the severity of various manifestations of asthenia based on the assessment of the effectiveness of passing the task on working memory (in accordance with the Stenberg paradigm [21]).

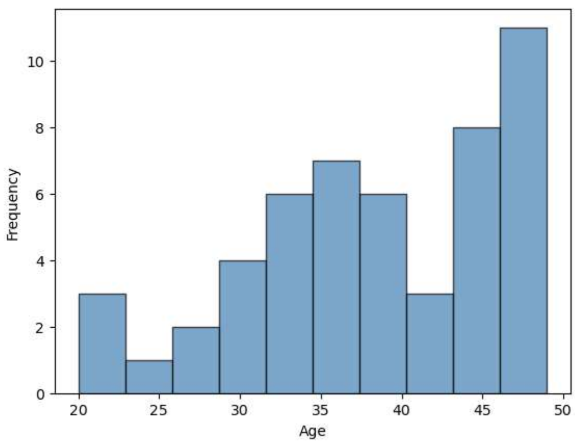

Fig. 1. Age distribution among patients.

II. Methods

The neurophysiological experiment was conducted with the participation of patients with subjective cognitive impairment and symptoms of asthenia aged 20 to 49 years (51 people in total, see Fig. 1). The level of asthenia and its type were detected using the subjective questionnaire MFI-20 (the subject was included in the sample if at least one of the scales of the questionnaire the sum of scores was 12 or more, or the sum of scores was more than 55, the median distribution is shown in the Fig. 2). The computer task based on the Sternberg paradigm was implemented as follows. The main experimental part begins and ends with recording the background activity of the subject for 60 seconds at rest. Each trial starts with a black background, which then displays a white cross for $1.5 - 2.5$ seconds to attract the attention of the subject. Next,

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an incentive appears in the form of a set of 8 characters, which contains from 3 to 8 capital Cyrillic letters, and the rest are "*". A set of letters is demonstrated for $1.5-2.5$ seconds, and the subject must memorize the letters shown. After showing a black background for $6-7$ seconds, a lowercase letter is displayed on the screen, and the person must answer whether the letter was in the previously shown character set or not. To determine the subjective level of mental fatigue, the subject had to record his subjective state of mental fatigue using a questionnaire in the intervals between four blocks, as well as before and after completing all trials (192 in total). The complexity of each trial was equal to the number of Cyrillic letters shown on the screen and ranged from 3 to 8 (32 trials of each complexity).

In order to evaluate the task performance in dynamics, we developed this method: the score system accrued/took away a certain number of scores in case of a correct/incorrect answer on each complexity:

1) Complexity "3": "$+1$" score for each correct answer, "-6" scores for each wrong answer;
2) Complexity "4": "$+2$" scores for each correct answer, "-5" score for each wrong answer;
3) Complexity "5": "$+3$" scores for each correct answer, "-4" scores for each wrong answer;
4) Complexity "6": "$+4$" scores for each correct answer, "-3" scores for each wrong answer;
5) Complexity "7": "$+5$" scores for each correct answer, "-2" scores for each wrong answer;
6) Complexity "8": "$+6$" scores for each correct answer, "-1" score for each wrong answer.

Skipping a trial of any complexity (when a subject didn't respond in time) gave 0 scores. Thus, the overall execution efficiency (E) can be calculated as: $E = \frac{1*(1-Er_3)-6*Er_3}{R_3} + \frac{2*(1-Er_4)-5*Er_4}{R_4} + \frac{3*(1-Er_5)-4*Er_5}{R_5} + \frac{4*(1-Er_6)-3*Er_6}{R_6} + \frac{5*(1-Er_7)-2*Er_7}{R_7} + \frac{6*(1-Er_8)-1*Er_3}{R_8}$, where Er_{3-8} is an error rate at the specified complexity, R_{3-8} is a Response time at the specified complexity

The formula for calculating the passing efficiency (E) of the task in an abbreviated form:

$$E = \sum_{i=1}^{6} \frac{i - 7Er_{i+2}}{R_{i+2}} \quad (1)$$

Here: Er_{i+2} – error rate with complexity equal to $i+2$, R_{i+2} – response time with complexity equal to $i+2$.

Our main task was to to find correlations between the results of MFI-20 and the results of cognitive task in patients using mathematical statistics methods.

III. Results

Firstly, there was no statistically significant correlation between the average response time or error rate and age of subject, his number of missed trials or the results of MFI-20.

Secondly, we found that the average subjective fatigue during the experiment is on average higher in people with higher scores on MFI-20 (see Fig. 3).

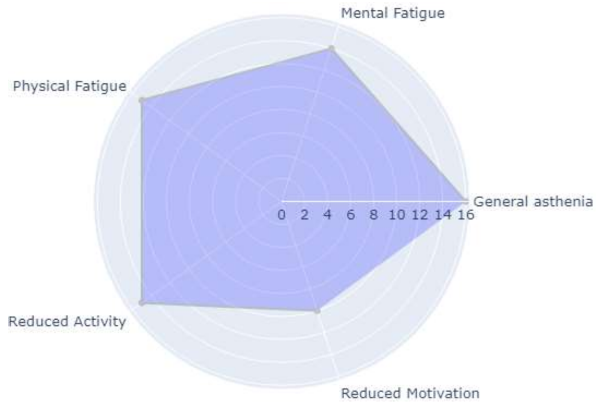

Fig. 2. Plot of median values of various types of fatigue (according to MFI-20) among patients.

Thirdly, during the Spearman's rank correlation analysis, we found that although there is a statistically significant correlation between the level of asthenia (according to MFI-20) and subjective fatigue during the experiment, this not only does not worsen the effectiveness of performance E, but on the contrary, people with high MFI-20 scores are somewhat better at solving problems compared to more people with lower scores according to this indicator. In addition, we found that such subjects tend to to be relatively better at solving non-targeted trials (see Fig. 3).

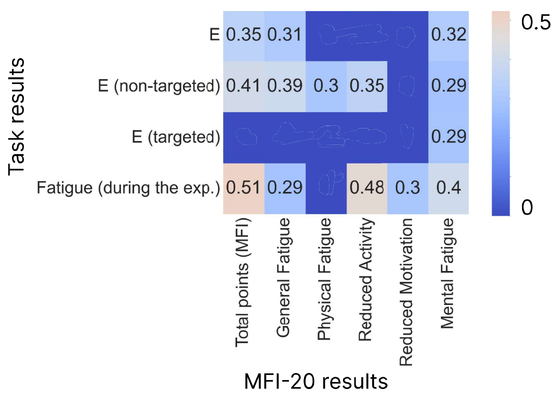

Fig. 3. Spearman rank correlation matrix with calculated efficiency E values (of all and targeted/non-targeted trials) and MFI results. Only statistically significant correlation ($p < 0.05$) coefficients r are shown.

IV. Discussion

Our findings demonstrate that individuals with more pronounced asthenic syndrome exhibit slightly higher efficiency in performing tasks related to working memory compared to those with less pronounced asthenia.

We believe this phenomenon may be attributed to what is known as "depression realism," wherein individuals with depressive manifestations tend to exhibit increased rationality and objectivity under cognitive load [22]–[24]. This could be linked to the higher metabolic costs of the brain, particularly associated with hippocampal disorders [25], in individuals with such cognitive impairments during the encoding/decoding of memories. Consequently, when faced with cognitive tasks, these individuals expend effort without restraint, leading to a heightened sense of mental fatigue, while maintaining the same objective effectiveness in their results. This effect is particularly evident in cases of mental asthenia, as we observed statistically significant correlations for both types of tasks (see Fig. 3).

CONCLUSION

We have proposed a scoring system to evaluate the dynamic effectiveness of a task on working memory. To the data obtained, we applied Spearman's correlation analysis to determine the statistical relationship between the performance of the task and the results of the subjective fatigue test. Statistically significant direct correlations between the effectiveness of passing the cognitive test and MFI-20 scores were revealed (Fig. 3). This means that, despite the fact that people with pronounced indicators of asthenia on the test, despite more significant subjective fatigue, are able to solve the test somewhat better than people with low indicators of asthenia (especially on non-target tasks). In addition, only mental asthenia is characterized by the same correlation coefficient for both targeted and non-targeted tasks.

Thus, the conclusions of this work have both applied significance - they serve as a starting point for improving diagnostic cognitive tests, and fundamental — this study demonstrates so unexpected results on how effectively the working memory of people with increased fatigue works.

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