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## Functional Asymmetry of the Brain: An Innovative Test for Left-Handedness and Leftness in Basic Neuroscience Research and Neurorehabilitation

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### ABSTRACT

**Introduction:** Fast and high-quality detection of leftyness can be very informative in pedagogy, professional selection, medicine. To do this, it is necessary to develop a test that should be informative, simple, concise, quick to conduct and calculate, not requiring special equipment, combining questions and tasks, revealing mainly persistent and unambiguous manifestations of leftyness in various aspects such as biographical, motor, sensory, mental ones.

**Goal:** to develop a universal test that provides reliable and rapid detection of signs of leftyness in healthy and sick subjects.

**Materials and Methods:** according to the developed protocol for leftyness detecting, consisting of 13 questions and samples, 210 people were studied, including 100 healthy persons and 110 patients randomly selected during neuropsychiatric or neuropsychological examination.

**Results:** test providing and protocol completion were fast, easily accessible both in the study of healthy and patients. When testing the primary protocol, it was found that: a) patients older than 30 years were less likely to report the presence of signs of leftyness, most of them preferred the right hand; b) women, compared with men, were more likely to report the presence of prophetic dreams and other variants of foresight; c) familial leftyness was more often found in patients compared with healthy persons d) according to most of the studied signes (7 out of 13), the largest proportion of patients with leftyness was found in patients with functional mental illnesses; e) significant correlations were found between biographical leftyness and left-handedness, as well as between left-handedness and ear leftyness. Based on the conducted research, a new improved protocol of test for the express detection of signs of leftyness (TEDSL) was created.

**Conclusion:** The modified TEDSL protocol developed as a result of this work is ready for use in further studies of various contingents of healthy and patients with various psychopathological symptoms.

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### Introduction

High interest in the reflection of individual functional asymmetry in the mental activity of healthy and sick people has led to numerous scientific studies and publications. However, their results have not yet been widely implemented in everyday practice. This is partly due to the desire of researchers to use special methods that require a long time, specialized equipment, and significant effort on the part of the researcher and the subject. The process and application

of a complex procedure for qualifying results is complicated by the presentation of data on functional asymmetry in quantitative form, often to the detriment of qualitative characteristics.

Since the mid-twentieth century, a number of monographic works are beginning to appear, proving the structural and functional asymmetry of the human central nervous system [1]. Interhemispheric interaction manifests itself in the form of motor, sensory and mental asymmetries, which can be assessed by objective research methods. It should be taken into account that the concept of leftyness has now expanded and is not limited to the

dominance of the left hand, but takes into account the lateralization of all paired organs (arms, legs, eyes, ears) [2]. Each subject has a unique combination of them, which determines the individual profile of functional asymmetry, which has completely different degrees of severity. Which may be an etiopathogenetic factor for various diseases [1]. Thus, understanding the mechanism of regulation of interhemispheric interaction opens up the possibility of comprehensive care for patients by specialists of various profiles and is an important fundamental problem, which determines the goal of our research. The asymmetry profile is determined by hereditary and gender characteristics. It can change with age and under the influence of environmental and stress factors, as well as congenital and acquired diseases of the central nervous system. Structurally similar cerebral hemispheres have significant functional differences. Normally, their interaction on the principle of complementarity is ensured by commissural nerve fibers, of which the largest is the corpus callosum. The fibers of the corpus callosum connect all homotopic areas of the neopallium of the left and right hemispheres, with the exception of the primary projection fields. The corpus callosum is a marker for functional lateralization because its size is proportional to the number of nerve fibers. But there are conflicting studies in which the size of the corpus callosum correlates with both an increase and a decrease in functional asymmetry [3]. Functional lateralization of the cerebral cortex mainly relates to the conscious sphere and its product is the formation of balanced neuropsychic activity. At the same time, it should be remembered that any form of intellectual activity requires the mandatory friendly participation of the neopallium of the two hemispheres of the brain. Thus, with a decrease in functional asymmetry, the efficiency of brain activity and, including, a person's intellectual abilities decreases [4].

Meanwhile, a quick and high-quality determination of the profile of functional asymmetry, and, more simply, the answer to the question whether a person has signs of left-handedness and in what area they manifest themselves, can be very informative in pedagogy, professional selection, medicine, in particular, the management of patients with psychopathological manifestations of various

diseases [5-12]. Leftyness require a special approach in school, professional and academic education, in psychoprophylaxis, as well as in the diagnosis, treatment and rehabilitation of patients, especially when they develop neuropsychiatric disorders [11-16]. All of the above necessitates the development of a universal test that provides reliable and rapid identification of signs of leftyness in healthy and sick subjects.

Such a test should be informative, simple, brief, quick to conduct and evaluate, not requiring special equipment, combining questions and tasks (tests), identifying predominantly persistent and unambiguous manifestations of leftyness in various aspects - biographical, motor, sensory, mental.

### The Objectives of this Study were

1. Creation of a primary protocol for identifying leftyness
2. Testing suitability of the created protocol on healthy and neuropsychiatric patients
3. Analysis of the dependence of the frequency of detection of leftyness on age and gender factors
4. Comparison of the proportion of leftyness in healthy subjects and neuropsychiatric patients, and among the latter – in patients with and without structural epilepsy
5. Identification of correlations between individual signs of leftyness
6. Modification of the initial protocol for use in further studies

### Material and Methods

Based on numerous own preliminary studies, 13 questions and samples were selected that were included in the primary protocol for identifying leftyness (see Figure 1) [17-31]. Unlike narrowly targeted questionnaires or individual experimental methods aimed at studying asymmetry only in hearing or vision, the proposed test is comprehensive, helps to identify not only motor (arm, leg), but also family, and sensory (eye, ear), and mental leftyness (prophetic dreams and foresight, mirroring in writing with two hands), contains both questions and simple tests [32-34].

Protocol for express detection of left-handedness from \_\_\_\_\_

Last name/First name \_\_\_\_\_ Sex \_\_\_\_\_ Age \_\_\_\_\_ Specialization \_\_\_\_\_

Diagnosis \_\_\_\_\_

Family leftyness(who) \_\_\_\_\_ yes no

Self-assessment (P-righty, O-no preferences, L-leftyness) \_\_\_\_\_ P O L

Was there any retraining \_\_\_\_\_ yes no

The preferred hand in everyday life (letter, paint, eating) \_\_\_\_\_ P O L

Which hand is more active in applause \_\_\_\_\_ P O L

Long jump push leg \_\_\_\_\_ P O L

Which leg does he use to draw the number 5 while sitting \_\_\_\_\_ P O L

Aiming eye when shooting \_\_\_\_\_ P O L

Which eye remains open when winking \_\_\_\_\_ P O L

Which ear is the telephone receiver placed on \_\_\_\_\_ P O L

Which ear listens to the clock \_\_\_\_\_ P O L

Are there prophetic dreams \_\_\_\_\_ yes no

Mirroring in writing numbers with both hands with eyes closed. \_\_\_\_\_ yes no

Figure 1: Primary Protocol for Rapid Detection of Signs of Leftyness Used in this study

to the presented protocol, a total of 210 people were studied, 70 men, 140 women, with an average age of  $37.1 \pm 2.0$  years

Among those examined were 100 healthy subjects (colleagues, acquaintances and family members of the researchers) and 110 patients randomly selected during neuropsychiatric or neuropsychological examinations, among whom patients with structural epilepsy predominated (72 patients); there were fewer patients with neurosurgical and neurological diseases without structural epilepsy (17), with functional mental (21), including endogenous (12) and neurotic (9) disorders.

The significance of group differences was assessed using the Pearson chi-square test, and the relationship between characteristics was assessed by calculating the rank or tetrachoric correlation coefficient [35-38].

## Results

As expected, completing the test and completing the protocol was quick (took from 2 to 5 minutes), easily accessible both in the study of healthy people and patients, including in observations with significant cognitive decline, endogenous and neurotic diseases. Significant difficulties were noted only in the presence of severe sensory aphasia. When analyzing the influence of age differences, negative correlations were revealed between age and left-handedness in self-esteem ( $p < 0.05$ ) and in preference for the left hand in everyday life ( $p < 0.05$ ). Patients over 30 years of age were much less likely to report signs of leftness; most of them preferred their right hand in all everyday activities. When analyzing the gender factor, it was found that women, compared to men, more often reported having prophetic dreams and other types of foresight ( $p < 0.05$ ). The distribution of identified signs of leftness in the studied groups is presented in Table No: 1.

**Table 1: Proportion of Patients with Various Signs of Leftness (In%) in the Studied Groups**

| Types of leftness           | Healthy (N=100) | Patients with structural epilepsy (N=72) | Patients without structural epilepsy (N=38) |
|-----------------------------|-----------------|--|---|
| Family                      | 18,0            | 31,9+                                    | 37,8++                                      |
| In self-esteem              | 14,0            | 8,4                                      | 26,3  |
| Relearning in childhood     | 8,2             | 5,6                                      | 16,2  |
| Hand in everyday life       | 10,5            | 12,5                                     | 26,3+*                                      |
| In applause                 | 34,7            | 30,6                                     | 38,0  |
| Push legs                   | 50,5            | 52,2                                     | 63,1  |
| In a letter with your foot  | 13,3            | 16,7                                     | 13,1  |
| In sight                    | 34,3            | 40,3                                     | 39,4  |
| When winking                | 55,0            | 52,9                                     | 44,7  |
| In listening to the phone   | 37,4            | 22,2                                     | 50,0*                                       |
| In listening to the clock   | 53,1*           | 17,7                                     | 47,4*                                       |
| Prophetic dreams, foresight | 61,0            | 47,2                                     | 54,1  |
| Mirroring in writing        | 34,0            | 33,3                                     | 21,1  |

+ and ++ - more common left-handedness compared to healthy people,  $p < 0.05$  and  $p < 0.01$ , respectively

\*-more common left-handedness compared to the group of patients with structural epilepsy,  $p < 0.05$

As can be seen from the table, significant differences between the groups were that familial leftness was found significantly more often in patients compared to healthy subjects, and leftness listening to a clock was significantly less common in patients with structural epilepsy compared to healthy subjects and patients without structural epilepsy. For most of the studied indicators (7 out of 13), the largest proportion of patients with left-handedness was in patients without structural epilepsy. At the same time, the differences reached the level of statistical significance in relation to: 1) left-handedness in the hand in everyday life compared to healthy people and patients with epilepsy, and 2) in the ear when listening to the phone compared to patients with structural epilepsy. These differences persisted when 17 neurosurgical and neurological patients were excluded from this group, that is, they were significant specifically for 21 patients with functional mental illnesses.

at the second stage of the analysis, connections between individual manifestations of leftness were studied. statistically significant relationships were identified between

- family left-handedness and self-esteem ( $p < 0.05$ )
- self-esteem and relearning in childhood ( $p < 0.01$ )
- preferred hand in everyday life and applause ( $p < 0.01$ )
- aiming eye and winking ( $p < 0.01$ )
- preferred ear when listening to the phone and watch ( $p < 0.05$ )

The connections between: a) family leftness and relearning ( $p > 0.05$ ), b) jogging and writing with the foot ( $p > 0.05$ ), c) prophetic dreams and/or foresight and mirroring in the signature by two hands ( $p > 0.05$ ).

When the studied indicators were enlarged into 6 groups, the correlations presented in Table 2 were obtained.

**Table 2: Tetrachoric Correlations between Different Types of Leftyness**

|              | Biographical | Hand  | Foot  | Eye   | Ear   | Mental |
|--------------|--------------|-------|-------|-------|-------|--------|
| Biographical | 1,0          | 0,3*  | 0,19  | 0,10  | 0,20  | 0,15   |
| Hand         | 0,3*         | 1,0   | 0,14  | 0,09  | 0,33* | 0,03   |
| Foot         | 0,19         | 0,14  | 1,0   | -0,03 | 0,14  | -0,03  |
| Eye          | 0,10         | 0,09  | -0,03 | 1,0   | 0,00  | 0,04   |
| Ear          | 0,20         | 0,33* | 0,14  | 0,00  | 1,0   | 0,08   |
| Mental       | 0,15         | 0,03  | -0,03 | 0,04  | 0,08  | 1,0    |

\* -  $p < 0,05$

As can be seen from the table, significant correlations were found between biographical left-handedness and leftyness by hand, as well as between left-handedness by hand and leftyness by ear. The remaining correlations did not reach the level of statistical significance. The main result of this study was the creation of a new improved test protocol for the rapid identification of signs of leftyness (see Figure 2).

Protocol for express detection of leftyness from \_\_\_\_\_

Last name/First Name \_\_\_\_\_ Sex \_\_\_\_\_ Age \_\_\_\_\_ Specialization \_\_\_\_\_

Diagnosis \_\_\_\_\_

- The answer to the question: Are there any left-handed relatives? (not - P, grandmothers, grandfathers, aunts, uncles, nephews-O, mother father sister brother-L). \_\_\_\_\_ P O L U
- Self-assessment (P-righty, O-no preferences, L-leftyness, U- unknown) P O L U
- Was there any retraining \_\_\_\_\_ P O L U
- The preferred hand in everyday life (letter, paint, eating) \_\_\_\_\_ P O L U
- Which hand is more active in applause \_\_\_\_\_ P O L U
- Long jump push leg \_\_\_\_\_ P O L U
- Which leg does he use to draw the number 5 while sitting \_\_\_\_\_ P O L U
- Aiming eye when shooting \_\_\_\_\_ P O L U
- Which eye remains open when winking \_\_\_\_\_ P O L U
- Are there prophetic dreams \_\_\_\_\_ P O L U
- Which ear is the telephone receiver placed on \_\_\_\_\_ P O L U
- Which ear listens to the clock \_\_\_\_\_ P O L U
- Are there prophetic dreams \_\_\_\_\_ P O L U
- Is left or right confusing?
- Mirroring in writing numbers 245, 369 with both hands with eyes closed \_\_\_\_\_ P O L U

**Figure 2:** Protocol for Express Detection of Signs of Leftyness, Adjusted as a Result of the Study

**In this New protocol, Unlike the Original**

- Gradations of family leftyness, the fact of relearning from left-handedness to rightyness, the phenomena of foresight and mirroring in writing have been introduced.
- The “push leg” test has been replaced by the preferred foot when striking the ball.
- Two questions regarding the possible identification of mental leftyness have been clarified and added, revealing anticipation of the future and mirroring in mental activity.

**Discussion**

This report presents an attempt to develop and use a test for rapid detection of signs of leftyness, which resulted in the creation of an improved protocol that requires extensive follow-up studies on various populations of healthy and sick people. The protocol appears to be applicable, convenient and informative when examining both healthy and neuropsychiatric patients. The

limitation of the proposed approach is that the created protocol, specially designed to identify persistent signs of leftyness, refers to stationary methods and is not very suitable for studying the dynamics of functional asymmetry, which requires other, quantitative and sensitive to changes parameters. The patterns discovered during testing of the initial version of the protocol require further verification in larger and more homogeneous groups [39].

The revealed fact of less frequent left-handedness in self-esteem and preference for the left hand in everyday life among subjects over 30 years of age can be explained by the fact that their upbringing and ontogenetic development occurred at a time when the presence of leftyness, unlike the majority in our country, was considered incorrect and undesirable [34]. In recent decades, the situation has changed, individual differences have become more studied and even welcomed, and therefore there

are more people who consider themselves left-handed and prefer their left hand in some everyday skills. The finding that women, compared to men, more often reported the presence of prophetic dreams and other types of foresight may be due to the greater representation of sensory cognition in the mental life of women, with a corresponding tendency towards mystical thinking. It was somewhat unexpected that the higher frequency of identifying individual signs of leftyness among neuropsychiatric patients compared to healthy people was confirmed at the level of statistical significance only in relation to familial left-handedness, while in relation to the preferred left hand this turned out to be true only when comparing groups of healthy people and patients without structural epilepsy, in which functional mental disorders predominated.

An analysis of correlations between individual signs of leftyness revealed statistically significant connections not only between left-handedness and leftyness in biographical data, but also between leftyness and left-handedness by ear. The remaining signs of leftyness turned out to have little connection with each other. Therefore, it seems necessary to further analyze the contribution of each type of leftyness to the phenomena being studied - mental characteristics, learning ability, reactions to stress, psychopharmacotherapy, etc [40].

### Conclusion

The modified test protocol developed as a result of this study for the rapid identification of signs of leftyness (TEPL) is ready for use in further studies of various populations of healthy people and patients with various psychopathological symptoms. The correlations identified in this work need to be tested in larger groups. The authors gather themselves and invite other researchers to take part in testing the latest improved version of TEVPL, comparing the results obtained with its help with practically important parameters of school and vocational training, psychoprophylaxis, as well as diagnosis, treatment and rehabilitation of patients of various profiles.

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