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## **A MEANS OF FIELD DIAGNOSTICS OF MOTOR MANIFESTATION OF LATERALITY AND ITS FLAWS\***

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### **SUMMARY**

The aim of this study is to describe the current state of field diagnostics of motor manifestations of laterality and cerebral dominance, to show which diagnostic tools are used and what their weaknesses are. It was discovered that the questionnaire which is often created only for adult population is the most frequent tool. There is hardly ever scientifically elaborated methodology and reasoned diagnostic quality of these tools. Motor tests focusing on the comparability of performance and the quality of a motor task in two similar motive organs are only used to limited extend. Due to the complexity of functional asymmetry of cerebral hemispheres, we suppose to that the questionnaire preference method can only be regarded as a rough estimate of the real cerebral dominance.

**Key words:** cerebral dominance, preference, proficiency, test battery<sup>2</sup>

### **INTRODUCTION – HISTORY AND CURRENT SITUATION OF LATERALITY RESEARCH**

The research of laterality as the dominance of one side of the body or the preference of the use of one of paired organs in relation to the functional asymmetry of cerebral hemispheres has been investigated by specialists for almost 200 years. During that time, many works dealing with mutual relations of laterality, mental disorders, asymmetry and cerebral dominance have been written. Laterality can be either morphological or functional. Morphological laterality assesses disproportions of parts of the body and organs (Mohr et al., 2003). Functional laterality is understood as asymmetry of motive (hands, legs) or sensory (an eye, ear) paired organs (Hatta et al., 2005) that is demonstrated by preferred use of one of the paired organs. The organ works faster or with better quality and reflects the dominance of one of the cerebral hemispheres (Barut et al., 2007). Laterality is mostly related to neurology and psychology, especially in the area of diagnostics of specific disorders (Johnson, 2005).

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The first significant studies dealing with laterality appeared in medicine. In the second half of 19<sup>th</sup> century, the cross-lateral function of brain (the right half of the body is motor-driven by the left hemisphere and the other way round) (McManus, 2002) in patients who had suffered a stroke and half of their body in the sagittal plane was paralyzed was discovered by autopsy. Despite the discoveries, the left-handedness was still considered as pathology. The centre of speech, the so called Brocca's area, which, in right-handed people, was almost always situated in the left hemisphere, was localized along with the above mentioned discovery. In the 1930s, a prominent pathologist of speech S. T. Orton published a monograph *Reading, Writing and Speech Problems in Children: A Presentation of Certain Types of Disorders in the Development of the Language Faculty, in which he pointed at the relation between insufficient dominance of one of the hemispheres and speech and writing disorders in children. Studies based on medical and psychometric research dealt with relations and diagnostics of laterality in motive and sensory organs* (Green et al., 1989; Kimura, 1964; Nagae, 1983). Results of these works showed that the functional laterality and its diagnostics is essential when resolving the issues of causes of specific disorders in children, pathologies in psychiatric disciplines (schizophrenia) (Taylor et al., 1980) and in career diagnostics. In former Czechoslovakia, the issue of laterality and its diagnostics was best dealt with in the studies by professor Sovák (1962). These studies mainly researched into psychological disorders of naturally left-handed children who were forced into retraining (to become right-handed).

## PROBLEM

Currently, there is quantity of diagnostics tools which are used to detect motor laterality manifestation. We suggest that most of them are not on scientific methodology based and their construction grow up only from needs of clinical practise. The aim of this study is to describe the current state of field diagnostics of motor manifestations of laterality and cerebral dominance, to show which diagnostic tools are used and what their weaknesses are.

## MEANS OF FIELD DIAGNOSTICS OF MOTOR LATERALITY

A range of diagnostic tools is currently used in the world to identify motor demonstrations of laterality. These are mainly questionnaires (Anett, 1970a); Coren & Porac, 1978; Oldfield, 1971; Coren, 1993; Elias et al., 1998) used, above all, in neurology and psychiatry. In the Czech Republic, the best-known is the test battery "Zkouška laterality" (Laterality Test) (Matějček & Žlab, 1972), created at the beginning of the 1970s, which by a way of motor preferential tasks determines the laterality of a hand and eye in both children and adults. Among disciplines making use of this diagnostic tool in the Czech Republic are phoniatriy (the laterality of a hand is related to the function of the centre of speech) and special education.

## QUESTIONNAIRES

The most frequently used diagnostic tools are questionnaires which are drawn up mainly to determine the preference of the upper and the lower extremity without giving an option to compare the degree of lateralization or discovering a possible retraining of the tested individual. It is the reason why the questions in a questionnaire are usually unimanual, ergo an individual only chooses between the left and the right extremity. This means of diagnostics of laterality contains several difficulties. It mostly distinguishes three types of laterality depending on whether the activity is carried out by the right hand, left hand or by both right and left hands (Anett, 1970a; Coren & Porac, 1978; Oldfield, 1971). Each of these answer options has its own value in the questionnaire; the right hand +1, the left hand -1, both left and right hands are valued as 0. According to the quotient calculated from the results of the answers from the questionnaire given as percentage, an individual is placed on the Likert Scale (of laterality) (Barut et al., 2007; Coren & Porac, 1978; Chapman et al., 1987; Oldfield, 1971 and others). In their itemized questionnaire, authors Coren and Porac calculate dexterity and sinistery by merely adding up individual figures. For example, if the result of an individual in the questionnaire consisting of eight items is positive, the diagnosed individual is considered right-handed. We believe that the determination of laterality in the range from +1 to +8 is very vague, especially if all the items are assigned the same value (loading). In some studies, there are even five options of answers. Apart from the three mentioned above, these additional options are added: I usually carry out the activity with my right hand, I usually carry out the activity with my left hand (Sherman & Kulhavy, 1976). However, the meaning of the word *usually* is not clearly defined there. In some questionnaires, there are even options *occasionally* or *mildly*. There is no grounded procedure to determine the degree of lateralization (sidedness), so the obtained data can be considerably misleading, especially when considering that handedness has not been put into the category of ordinal data. Recently, a confirmatory factor analysis of the world's best-known questionnaire called "Edinburgh Inventory" (Oldfield, 1971) has been carried out and it was found that three out of the ten items of the questionnaire are redundant (Dragovic, 2004).

Authors Bishop, Ross, Daniels and Brigit (1996) state that there is no golden standard even for the determination of handedness. Different investigators use different tasks or questionnaires and in almost all the cases they take decisions arbitrarily on what to call the subgroups of handedness and with what division (Anett, 2002). All preferential questionnaires used nowadays have also been drawn up from evaluation of results from adult population. For the population at risk, children between 7 and 12 years of age, no diagnostic tools that would sufficiently differentiate the lateralization of an individual have been developed.

Questionnaires were also upgraded with items diagnosing the dominance of sensory organs, particularly eyedness and earedness. However, ocular dominance (eyedness) is a far more complicated asymmetry and so far, only hypotheses have been pronounced about its foundation. Several studies have dealt with the relation of ocular dominance and nerve roots. The hypothesis looking for the origin (manifestation) of asymmetry in the movement of motor control of eyes is the most supported one (Annett, 1985; Bourassa et al., 1996). Money (1972) gives evidence in tachistoscopic experiments where better precision of perception with the dominant eye was found in situations that demand quick

control (motor control). Other studies state the discovery of orthogonal factors for ocular dominance; the observational factor – observation of distant objects, the sensory factor (binocular rivalry) – ocular dominance during simultaneous observation of two different objects and the acuity factor – the ability to distinguish the details of an observed object. The observational factor is the most frequently used one to determine ocular dominance; the participant is asked which eye s/he would use when looking through e.g.: a telescope. Nevertheless, this model of discovering ocular dominance does not always correspond with the ocular dominance of space perception – binocular rivalry (Norman et al., 2000). It is interesting that in their study Bourassa et al. (1996) consider the questionnaire a better diagnostic tool for the measurement of eyedness than the result of the motor task itself.

The determination of auricular dominance is also a very complicated issue. It has been discovered that each hemisphere performs its function in sound coding in a different way. The right hemisphere identifies better the pitch and timbre of a tone. The left hemisphere is better at perceiving the changes of sound in time – the speech (Tervaniemi & Hugdahl, 2003). Simple questionnaire questions that were composed on the basis of hypotheses on the relation between footedness and earedness certainly cannot precisely determine auricular dominance.

In the course of the 70s', more questionnaires were created all around the world (Kovac, 1973; Raczkowski, et al., 1974; Sherman & Kulhavy, 1976). Due to their duplicity with *Edinburgh Inventory* (Oldfield, 1971), they are not used.

## MOTOR TASKS AND TESTS

To determine the preference of upper and lower extremities, a number of motor tasks and tests, which, according to only some authors, are predictors of higher quality when it comes to the laterality determination of an individual (Anett, 1970b), were created in the past. The creators of preferential questionnaires cast doubt upon the creation and the use of motor tasks or tests due to the unproved higher validity and reliability as well as the fact that processing them is time-consuming (Sherman & Kulhavy, 1976; Bryden et al., 2000; Oldfield, 1971). Even nowadays, *Harris test of laterality* (Harris, 1958) is among the best known tests worldwide. However, items of this diagnostic tool are based on some sort of intuition and logic validity of particular indicators and no fundamental diagnostic quality is defined. In the Czech Republic (Czechoslovakia), a number of experts: (Sovák, 1962; Kučera, 1961; Matějček & Žlab, 1972; Zaháněl & Vaverka, 1990) has been engaged in the creation of motor tasks in order to determine laterality. In the Czech Republic, the best-known is “Zkouška laterality” by professor Matějček and doctor Žlab (Matějček & Žlab, 1972). For the calculation of the laterality quotient, these authors adopted the mathematical formula from questionnaire studies “Edinburgh Handedness Inventory” (Oldfield, 1971). The authors chose tasks that were labelled as highly valid in relevant literature. Nevertheless, these motor tasks were created exclusively to satisfy the needs of clinical practice and were not properly validated. Individual items are tasks of unimanual and bimanual nature (tasks where one extremity performs the control and the other one's function is auxiliary). However, motor preferential tasks do not precisely represent the degree of lateralization of an individual.

## MOTOR PROFICIENCY

The proficiency component has been neglected in the test batteries that have been used so far. Motor proficiency focuses on the comparability of the performance and the quality of the execution of a motor task (or test) by two similar motive organs and the comparability is assessed by proficiency motor tests. Motor tests that are called proficiency are also labelled performance tests in literature. For example, tapping of the upper extremity – the pointing test without space limitations, the strength of a squeeze of a hand – the manual dynamometer or the pegboard test are among them (Porac, 2009; Rigal, 1992). The pegboard test was first designed by Marion Annett. It is a board with small slots for pegs. The tested person has to put the pegs into the slots in a given time, first with the preferred and then with the non-preferred hand (Anett, 1970b). However, examiners often struggle with the issue of imitation when the tested individuals did not show any objectively significant difference in the number of inserted pegs with their preferred and non-preferred hands even after practice. Another proficiency test in use was the so called “modified dotting test” (dot circles). The main aim is to place one dot into each of the specified circles with the diameter of 4 mm using a pencil. This test is again performed by both the preferred and the non-preferred hand (Bryden, 1982). Experts dealing with the diagnostics of laterality still do not want to entirely accept proficiency tests (performance tasks) due to their demands on time and many studies supporting the method of preferential questionnaires point at their redundancy. According to Peters, the hypothesis that preference and proficiency are closely related is right. He states that the emphasis should be put especially on the relation between preference and proficiency (quality and performance of motive organs), (Peters, 1998; Wachter et al., 2008). However, this relationship is neither further specified nor statistically expressed by any other means. General characteristics and the definition of proficiency of handedness in children were investigated by Gabbard (Gabbard et al., 1997). A test battery that would enable a more complex diagnostics of motor proficiency (performance) of motive organs along with the determination of spatial dominance of the eye has not been fully developed.

## CONCLUSION

In this study, we have described the current situation and means of field diagnostics of motor manifestations of laterality. The above given review implies that there is no unified view of the determination of motor manifestations of laterality that would also provide the basis for the development of a clear concept of diagnostics.

In case of the already created diagnostic tools, their scientific conclusiveness is not fully elaborated and some of them lack the basic formulation of the diagnostic quality of the created tool such as validity (especially problematic of construct validity) and reliability (specific, generic). We suggest that the questionnaire form of diagnostics of motor laterality manifestation is helpful for raw basic assessing of discrimination between right handers, lefthanders but it is not enough sophisticated method for approximation of hemispherical specialization. We also believe that the absence of a quality standardized diagnostic tool for the diagnostics of motor manifestations of laterality in children, especially in age

category from 7 to 10, constitutes yet another problem. Nowadays, children are diagnosed in two ways. They either fill in a questionnaire on hand and leg preference that is based on research and testing of adult population or children are diagnosed by a way of simple motor tasks which lack scientifically justified diagnostic quality.

## DISCUSSION

Consequently, we believe that preferential questionnaires as diagnostic tools are not satisfactory for the needs of quality field diagnostics of motor manifestations of laterality. From the conclusion of this study it is obvious that for improvement in the quality of diagnostics of motor laterality manifestation it would be useful to create tests batteries with solid methodological base. That it will be necessary to include the component of proficiency into the diagnostics, which enables comparability of performance and quality of execution of a motor task (or test) of two similar motive organs. One test battery for children in the age of 7 to 10, which should contain part of preference tasks and part of proficiency tests, concentrated on fine motor of upper and lower limbs in accordance with ontogenetic of their behave. The test battery for adult subjects should contain moreover the preference tasks and proficiency part very short questionnaire part for basic raw screening of hand and leg preference.

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## **ZPŮSOBY TERÉNNÍ DIAGNOSTIKY MOTORICKÝCH PROJEVŮ LATERALITY A JEJÍ NEDOSTATKY**

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### **SOUHRN**

Cílem této studie je popsat současný stav terénní diagnostiky motorických projevů laterality a cerebrální dominance, ukázat jaké diagnostické nástroje jsou používány a kde mají své nedostatky. Bylo zjištěno, že nejčastěji používáním diagnostickým nástrojem je dotazník, který je vytvořen velmi často pouze pro dospělé populaci. Chybí vědecky propracovaná metodologie a zdůvodněná diagnostická kvalita těchto nástrojů. Pouze v omezené míře jsou využívány proficienční motorické testy, které jsou zaměřeny na porovnatelnost výkonu a kvality provedení motorického úkolu dvou stejných hybných orgánů. Vzhledem ke složitosti funkční asymetrie mozkových hemisfér se domníváme, že dotazníkovou metodu preference lze považovat pouze jako hrubý odhad skutečné cerebrální dominance.

**Klíčová slova:** cerebrální dominance, preference, proficienční motorické testy

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