

# PSYCHO-PHYSIOLOGICAL PRECONDITIONS FOR THE INDIVIDUALISATION OF TEACHING/ LEARNING PROCESS FOR LEFTHANDERS

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## Abstract

*One of the basic principles in organising educational (teaching/learning) process is individualisation, in other words - ensuring opportunities and environment for successful learning considering individual students' personal characteristics. Approximately 10% of our society is the so called left-handers - people with a dominant left hand. Obviously we encounter them at school, too. Left-handed children differ in the ways how they perceive information, analyse space and time, think and feel, i.e. in their psycho-physiological processes.*

*Our work deals with research results obtained by means of psycho-physiological testing: e.g. the computerised DT (Determination Test) S1 version and MLS (Motor performance series) test from Vienna Test System. The acquired results reveal that left-handers differ from right-handers in such psycho-physiological aspects as attention distribution and stability, information perception and processing, reaction to conflict situations and reactive stress duration. The former also consume more oxygen while under pressure than the latter.*

*The research results indicate that left-handers require an individual educational approach.*

**Key words:** *functional asymmetry of brain hemispheres, lefthanders, right-handers, attention, educational (teaching/learning) process.*

## Introduction

One of the basic principles in organising educational (teaching/learning) process is individualisation, in other words - ensuring opportunities and environment for successful learning considering individual students' personal characteristics. Or, according to I. Beļickis (2000) - ensure a pedagogical situation in which a "value-oriented atmosphere" prevails. Humane-education (Gudjons, 1998) focuses on human as a whole, attempting to understand each individual's actions and behaviour, and stresses student-centred education, with a child (student) in the centre of attention ( as opposed to the subject-centred approach). The 21<sup>st</sup> century education follows the child's interests, needs and abilities instead of foregone verities (Špona, 2001).

Unlike differentiation which focuses on high academic achievements in separate subjects ensured by considering students' talents and creative characteristics, individualisation envisages applying various educational methods, techniques and approaches in order to ensure

a certain level of academic achievement (established by the curriculum) for each student. It is an approach demanding high pedagogical skill and knowledge of each student's individual characteristics. I. Maslo (1995) speaks of educational individualisation in the historical aspect pointing out that even Jan Amos Komenský wrote about individual approach to educating individual children. Approximately 10% of our society is the so called lefthanders - people with a dominant left hand. Obviously we encounter them at school, too. Left-handed children possess a different pre-programmed physical and mental potential which can be observed in their behaviour.

Studies of brain function started in the 19<sup>th</sup> century (Paul Broca and Carl Wernicke) and reached their peak in the late 20<sup>th</sup> century, and have proven that the specific behaviour of left-handers is determined by the functional asymmetry and specialisation of brain hemispheres - functional differences in the right and left hemisphere. The left hemisphere ensures people's (right-handers') logical, rational and theoretical skills, whereas the right one is responsible for creativity and intuition (Zigmond et al, 1999; Warner, 2000; Geake, 2009). The left-handers may have it vice versa. The lateralisation of brain hemispheres develops along with the development of articulate speech. Left-handed children's psycho-physiological processes related to perceiving information, analysing space and time, thinking and emotions are different. Several recently conducted researches (Warner, 2000; Pelša, 2004) have clarified the most distinct left-handers' characteristics that should be considered in education. Left-handers are active and energetic, impetuous and very emotional, quite creative and highly imaginative. They use their energy resources economically, therefore at times seem to be tireless. Such children prefer diversity in their work which demands for high levels of accuracy. Their impetuosity can frequently lead to stress, just like their emotions and pressure may cause a stronger fear syndrome, drastic change in mood and unstable attention.

Even though the functional lateralisation of brain has been widely studied, children and adolescents' psycho-physiological features related to the functional asymmetry of brain have still been insufficiently investigated. Pedagogy, in particular, pays very little attention to this problem. Our aim was to detect the difference between children and adults with regard to individual psycho-physiological features related to the functional asymmetry of brain.

## Methodology of Research

Our psycho-physiological research involved 62 participants: 22 junior form pupils (10-11 years old), 22 students of both genders (aged 20-21) and 18 adult male athletes (aged 20-23); the latter were in excellent physical condition, according to Harvard Step-test indicators (Auliks, 1985). All participants were questioned to detect their brain profile regarding the lateralisation of sight, hearing and motor functions and later divided into two groups:

Group I - with dominant left hemisphere (right-handers);

Group II - with dominant right hemisphere (left-handers).

We tested school-children's ability to distribute attention by means of numbers-arrangement test, and their capacities of information perception and processing (speed of processing information, accuracy and productivity of work) by means of a proofreading test during which every participant, within a certain amount of time, has to look through 2000 printed characters and cross out one particular of them (Психологические тесты, 1999).

While testing the adult participants' (students') psycho-physiological indicators: quickness and accuracy of reaction, as well as quickness and accuracy of hand movements we applied the computerised DT (Determination Test) S1 version (Neuwirth, Benesch, 2003) and MLS (Motor performance series) test (Neuwirth, Benesch, 2003) from Vienna Test System.

We selected maximum oxygen consumption levels ( $V_{O_2 \max}$ ), which we detected by the

indirect method (Auliks, 1985), as the indicator of an individual's physical and mental working energy.

The results were statistically processed by means of the t-Test: Two- Sample Assuming Unequal Variances tool in Excel.

## Results of Research

The functional asymmetry of the large brain hemispheres, aside from being genetically predetermined, develops along with articulate speech. This functional specialisation of brain forms gradually alongside the development of speech and abstract thinking up to the age of 14-16 and reaches maximum during mature age (Pelša, 2004).

Young school-children's lateralisation levels are still insufficient, consequently there are significant differences observed in how left- and right-handers of this age perceive and process information within a 3 minute interval (Table 1). Only in the 4<sup>th</sup> minute, possibly due to higher determination, right-handers demonstrate an obviously higher rate of information processing ( $3.09 \pm 0.67$ ).

**Table 1. Rates of information processing for students with differing "dominant" hemisphere.**

Research participants	Information processing rates (bits per second)			
	1 <sup>st</sup> min	2 <sup>nd</sup> min	3 <sup>rd</sup> min	4 <sup>th</sup> min
Group I	$3.48 \pm 0.71$	$2.49 \pm 0.54$	$2.78 \pm 0.62$	$3.09 \pm 0.67$ *
Group II	$2.90 \pm 1.49$	$2.62 \pm 0.51$	$3.04 \pm 1.26$	$2.71 \pm 0.66$ *

\* Significant difference ( $p=0.05$ )

**Table 2. Accuracy for young school-children.**

Research participants	Accuracy of work			
	1 <sup>st</sup> min	2 <sup>nd</sup> min	3 <sup>rd</sup> min	4 <sup>th</sup> min
Group I	$0.94 \pm 0.04$ *	$0.98 \pm 0.04$ *	$0.88 \pm 0.01$ *	$0.99 \pm 0.03$
Group II	$0.97 \pm 0.04$ *	$0.91 \pm 0.03$ *	$0.98 \pm 0.03$ *	$0.99 \pm 0.01$

\* Significant difference ( $p=0.05$ )

The accuracy of intellectual work, detected by taking the number of accurately crossed-out characters, dividing it by the total number of crossed-out characters and adding up the number of mistakes (missed or incorrectly crossed-out characters), characterises an individual's attention capacities. The results show that lefthanders and right-handers' working accuracy significantly differs in the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> working minute. During the 1<sup>st</sup> and 3<sup>rd</sup> minute lefthanders are more accurate, whereas right-handers accuracy is higher during the 2<sup>nd</sup> minute (Table 2). This testifies that left-handers' emotions and impetuosity impede with their capacity to focus attention. Also the numbers-arrangement test (lasted for 2 minutes) revealed that only 29% of left-handers were able to hold their attention as opposed to the 80% of right-handers.

**Table 3. Working efficiency in young school-children.**

Research participants	Efficiency			
	1 <sup>st</sup> min	2 <sup>nd</sup> min	3 <sup>rd</sup> min	4 <sup>th</sup> min
Group I	369.95±72.38*	276.71±67.78*	308.50±72.20	343.80±76.71
Group II	320.00±146.14*	295.72±55.28*	343.60±130.50	312.78±82.17

\* Significant difference (p=0.05)

Working efficiency of young school-children, which depends on working rates and attention stability, was calculated multiplying the number of scanned characters by the accuracy indicator. The results revealed that efficiency is significantly different for left- and right-handers during the 1<sup>st</sup> and 2<sup>nd</sup> minute: during the first minute it is higher for right-handers, whereas during the second minute - left-handers are more efficient (Table 3). Although during the 3<sup>rd</sup> and 4<sup>th</sup> minute there are also evident differences, they are not statistically significant, and might have occurred due to large data dispersion. Adult students display higher levels of efficiency and information processing rates, respectively: efficiency - 436.07 for left-handers and 536.41 for right-handers; information processing rate - 4.10 for right-handers and 4.69 for left-handers. Evidently adult left-handers work more intensively than their right-handed counterparts. This means also more intensive energy consumption; maximum oxygen consumption indicator ( $V_{O_2 \max}$ ) is 64.82 for left-handers and 50.37 for right-handers (a statistically significant difference).

Adults and children's efficiency differs also dynamically. Children's efficiency levels fluctuate within the four minutes (Table 3), while adult right-handers' efficiency steadily increases: first minute 414.58; second - 413.22; third - 462.54; fourth - 475.28. Adult left-handers' efficiency levels fluctuate just like children's: first minute 586.59; second minute - 493.13; third minute - 529.50; fourth minute - 481.17.

**Table 4. Adult students' reaction rates and efficiency levels.**

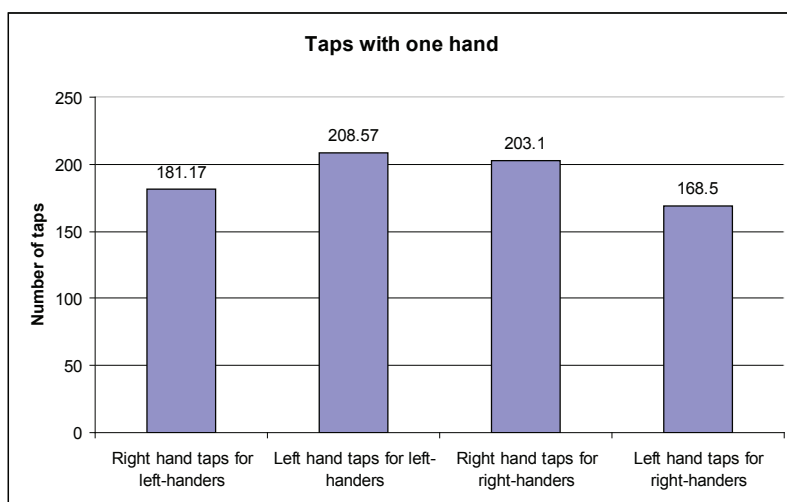
Research participants	Reaction numbers			Reaction rate (in seconds)
	Right	Wrong	Missed	
Group I	255.30±29.72	21.20±13.05	17.70±6.67	0.75±0.07
Group II	255.60±28.50	16.18±9.11	16.00±7.07	0.73±0.08

Using the computerised DT (Determination Test), we detected students' reaction to visual and acoustic stimuli. Working time limited - 4 minutes. Evaluating reaction rates along with right, wrong and missed reactions we can judge an individual's abilities to work under pressure and take decisions in limited time. While learning or studying, individuals have to experience a certain optimal level of stress (Krauklis, 1981). For an educator it is essential to organise educational process considering the psycho-physiological features of each particular age group. As shown by Table 4 all participants' reactions are within the norm: the norm for right answers is 175 - 278; for the wrong answers - 21-4 and for the missed ones - 20-4. Reaction numbers for right-handers and left-handers are not statistically different, however, right-handers have more wrong reactions (21.20±13.05) than left-handers (16.18±9.11). Reaction rates also do not differ significantly.

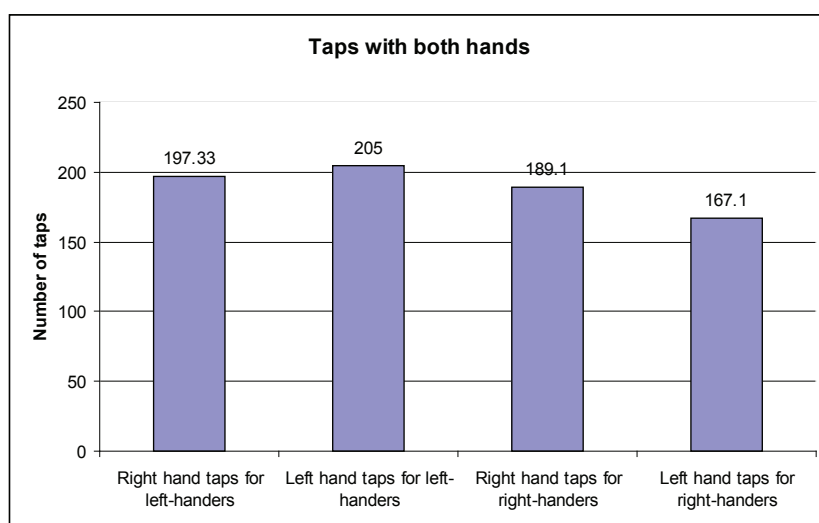
The number of wrong and missed reactions indicates attention stability. Adult left-handers and right-handers do not display significant differences as regards their reactions (Table 4) whereas left-handed and right-handed children's reactions differed remarkably during the

1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> minute (Table 2). This proves certain instability in children's brain hemisphere lateralisation, which decreases in mature age.

The MLS (Motor Performance Series) test reveals the specific characteristics of CNS functions (Figures 1 and 2). Hand motor capacities are measured by the number of taps on the working panel registered by computer. The test is carried out in two modes: working with one hand at a time and working with both hands simultaneously. While working with one hand statistically remarkable differences are observed in both right-handers (right hand -  $203.10 \pm 12.40$  taps; left hand -  $169.50 \pm 20.00$  taps) and left-handers (left hand -  $208.57 \pm 9.76$  taps; right hand -  $181.17 \pm 21.57$  taps). Comparing right-handers and left-handers' ability to work with the right hand we find no statistically remarkable differences ( $203.10 \pm 12.40$  and  $181.17 \pm 21.57$ ), while, regarding their ability to work with the left hand, left-handers remarkably surpass right-handers ( $208.57 \pm 9.76$  and  $169.50 \pm 20.00$ ).



**Figure 1. Motor performance of right and left hand in the one-hand working mode.**



**Figure 2. Motor performance of right and left hand in the both-hand working mode.**

While working with both hands simultaneously, left-handers do not demonstrate remarkable differences in the number of taps performed with each hand (left hand - 205, 00±11, 00; right hand - 197, 33±20, 73). Meanwhile right-handers demonstrate significant differences (right hand - 189, 10±22, 41; left hand - 167, 10±29, 86). This proves that right-handers' functional brain asymmetry is more stable and the dominance of the left hemisphere is more explicit than the dominance of the right hemisphere in left-handers. Similar conclusions are drawn also by other brain researchers. The group of young school-children could not be tested by means of MLS test since it is designed for persons above the age of 15.

## Discussion

A pedagogical process in which student-teacher interaction is organised to reach the target is the basis for the development of educated individuals. During continuous and productive processes of cognition, interaction and personality development, each individual (also a lefthander) acquires information, complements and consolidates knowledge, and develops new skills. Nowadays the problem of coordinating the manifold external influences, determined by environment, and the internal psychological processes, traits and states for a growing child, student and adult is still topical (Špona, 2001).

It is essential to organise the learning process so that children and youths could prove themselves and successfully apply their natural creative potential (talents, powers, will and capabilities). According to the majority of authors (Warner, 2000; Špona, 2001; Pejša, 2004, etc.), the 21<sup>st</sup> century educators make insufficient use of the latest discoveries in the field of neuro-psychology and psycho-physiology for the purpose of improving the quality of teaching/learning process. This regards especially the latest research results in the field of functional asymmetry and specialisation of human brain hemispheres. The authors of this article carried out a poll among teachers which revealed that 31% primary school and 40% basic school teachers misbelieve that left-handedness is related to dominant left brain hemisphere.

Primary school teachers regularly encounter problems with lefthanders: difficulties in acquiring reading and writing, difficulty to understand the concepts "left" and "right", inability to concentrate and focus on work. This explains the fact, revealed by the poll, that individual approach in work with lefthanders is more often used by primary school teachers (44%) and far less of then by basic school teachers (20%).

Currently schools view the lefthanders problem mostly from ergonomic perspective. Individual shops offer products for lefthanders - stationery, computer mouses, etc. Unfortunately too little attention is paid to the organisation of teaching /learning process and to the psycho-physiological processes ensuring a cognitive approach. This is particularly obvious in case of secondary school and university students - the group with stable brain hemisphere asymmetry (as proven by our research results), consolidated cognition processes and stabilised thinking. The authors would suggest that, alongside with conceptual pedagogical and psychological approaches, the ones based in psycho-physiology should be applied when working with these two age groups.



## Conclusions

Research results prove that information processing rates, working efficiency and accuracy, as well as attention stability differs in children and adult students depending on their dominant brain hemisphere. Children's information processing rates are lower than those of adults, however, at this age they do not remarkably differ for right-handers and left-handers. Accuracy rates, in turn, differ, mainly due to children's unstable attention, and are more evident in left-handed children.

During the 4 minutes of proofreading a text working efficiency for children and adults differs. Both right-handed and left-handed children demonstrate fluctuating levels of efficiency. Right-handed adults' efficiency grows by every minute, while left-handed adults' efficiency fluctuates just like children's. This proves the stability of brain hemisphere functional lateralisation in adult right-handers and left-handers.

Determination test results for adult students, evaluating reaction rates, as well as right, wrong and missed reactions, prove that both right- and left-handers are capable of working under pressure posed by educational tasks.

MLS test results for students prove the specific characteristics of brain hemispheres in right- and left-handers. While working with one hand, both groups demonstrate statistically remarkable differences depending on whether they are working with the dominant or the passive hand. The capability to work with the right hand does not differ between the groups, while the left-hand is obviously stronger for left-handers, which proves the functional dominance of their right brain hemisphere. Test participants working with both hands, it becomes obvious that right-handers' left brain hemisphere is functionally dominant as compared to the dominant right hemisphere in left-handers.

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