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Canonical Relations of Sensomotor Reactions of Bilateral Body Parts

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ABSTRACT

The research study was carried out on a sample of 20 subjects, of male gender, from 20 to 22 years of age. An analysis was carried out in the space of sensomotor reactions of bilateral (parallel, transversal, diagonal) body parts. The measuring of sensomotor reactions in bilateral body structures was developed through an especially constructed instrumentarium (Kinesiometer, M. Dodig, 1987). The obtained results have been processed by application of canonical correlational analysis (Cooley and Lohnes,1971). Based on maximum cohesion between the pair of linear functions of variable groups that measured sensomotor reactions (transversal, parallel, diagonal) body parts, characteristic canonical roots were extracted. In the field of transversal – parallel reactions of body parts, one pair of characteristic canonical roots, which explained 85% of joint variance. In the field of parallel and diagonal body parts, two characteristic canonical roots were extracted, the first explaining 86%, while the second one 61% of joint variance. In the field of diagonal and transversal body parts, two characteristic canonical roots were extracted, the first explaining 90%, the second 72% of joint variance. The obtained results indicate a topological and functional dependency of sensomotor reactions of bilateral (transversal, parallel, and parallel) body parts. An efficiency of functioning of the emission signal speed and the speed of the synaptic transmission (the number of synaptic ties and flow through synaptic barriers), efficient functioning of commissural relations between the hemispheres and the efficiency of afferent and efferent paths directed towards sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts can probably be found at the basis of these indicators.

Keywords: *canonical correlational analysis, canonical relations, sensomotor reactions, bilateral (transversal, parallel, and diagonal) body parts*

INTRODUCTION

The diversity of human motion and motor tasks, which he solves with any given body part as well as with the whole body are realized through various sensomotor reactions. The sensomotor reaction of the organism in a set time frame starts with one receptor reaction and ends with a muscle response directed at overcoming a certain path [7],[14],[15]. Motor processes and constructions, such as the sensomotor reaction, velocity, and motion coordination and others can be tied to the functioning of certain cerebral parts [8],[9],[10]. Sensomotor reactions vary in space and time with different modalities of displayed motor reactions, what enables identification of different sensomotor reactions of bilateral body parts [13]. The central nervous system plays a significant role within this. It consists of hundreds and thousands of separate neuron groups, within the scope of interactions of two hemispheres and collaboration among the hemispheres determines one of the basic mechanisms which enables continuity and complexity [1],[2],[3],[6]. Namely, with simple tasks, the resources of one hemisphere are for the most part sufficient for its analysis, thus the dominant mode of analysis here is within the hemispheres [16]. Data transfer from one hemisphere to the other requires a certain time and energy, the hemispheric asymmetry uses unilateral presentation of stimulus, while studies that utilize bilateral presentations can be used for a broader spectre of research [19]. In the case of unilateral stimulus, the stimulus incurs in just one field, that is, in one hemisphere, while the situation is somewhat more complex in the case of bilateral stimulus where stimuli incur simultaneously in two fields, that is, in two hemispheres. Namely, it is possible that differences in success of the two hemispheres reflect the differences in the efficacy of the hemispheres for analysis of certain data, but the effects of relations between hemispheres can also influence them. The functional feature of the bilateralization of sensomotor reactions allows for intermittent specialized cerebral mechanisms to develop, which often allow the selection of either left or right functions [4]. The human species separates this bilateral symmetry not only morphologically but functionally as well, what enables the application of a clearly differentiated evolved potential for solving sensomotor reactions by bilateral – transversal, parallel and diagonal body parts [17], [18], [20]. Numerous detached groups of fibres (afferent fibres) enter into these groups, while efferent fibres leave them [11]. Thus, the stimulus impulses are driven away from the senses via afferent neurons into different nerve centres, where transformation occurs and shifting to efferent neurons, which in turn come to the effector (muscle). Since sensomotor reactions of bilateral – transversal, parallel and diagonal body parts present a source of partial joint variability, and considering the explanation of the phenomenon of sensomotor reactions of bilateral body parts, a study was projected with the objective to research sensomotor reactions of bilateral – transversal, parallel and diagonal body parts.

METHODS

The sample subjects for this research list 20 subjects, male, ranging from 20 to 22 years of age. The planned sample ensures a reliability factor of 0.95, that every correlational coefficient is equal to or larger than 0.42, considers different from zero. The process of collecting data and setting parameters was conducted using an instrument called the KINESIOMETER (M. Dodig, 1987), hooked up to an electronic computer, with an adequate periphery, with application of program support for analogue – digital conversion in the programming language SIMON'S BASIC. The instrumentarium uses 8 important analogue – digital converters (ADC) to which the kinesiometer and signal system were directly plugged into and synchronized with the measuring system. The kinesiometer latched to body joints ensured transference of analogue sizes of body part reactions, which transform from electrical signals to digital impulses via an analogue-digital converter. The signal light system is directly connected to the converter, which is synchronized with the measurement system that has a maximum precision measurement of 2^{-8}, i.e. 256 parts of basic value. Measuring was conducted according to a specific program. The subject was situated in an adequate position with the attached instrumentarium and carried out certain reactions with motion. In this way obtaining significant data about the velocity of bilateral body parts is enabled. Measuring is conducted by way of an applied system for measuring in certain positions alongside solving various problems: (1) the subject is set on a background in a lying position on his back, with spread legs and arms next to his body to which kinesiometers are attached, (2) on a certain signal the subject exerts motion of arms and/or legs via transversal, parallel and diagonal body parts (picture 1).

Picture 1. Schematic overview of determinateness of bilateral body parts (A - transversal, B – parallel, C - diagonal).

In this way, groups of variables – data carriers of sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts – were isolated. Tests were marked with distinctive codes where the first two letters mark the space of sensomotor reaction (SR), the third letter marks the type of bilateral structure – transversal (T), parallel (P), and diagonal (D), the fourth and fifth letters the body part where the motion is realized, left leg (NL), left arm (RL), right leg (ND), right arm (RD).

(1) The variables for sensomotor reaction evaluation of transversal body parts (left leg – right leg, left arm – right arm); 1. (SRTNL), 2. (SRTND), 3. (SRTRL), 4. (SRTRD)
(2) The variables for sensomotor reaction evaluation of parallel body parts (left leg –left arm, right leg – right arm); 1. (SRPNL), 2. (SRPRL), 3. (SRPND), 4.(SRPRD)
(3) The variables for sensomotor reaction evaluation of diagonal body parts (left leg – right arm, right leg – left arm); 1. (SRDNL), 2. (SRDRD), 3. (SRDND), 4. (SRDRL)

The relations between the sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts are analysed through the technique of canonical correlational analysis (Coolly and Lohnes, 1971). For identification of significant canonical dimensions in addition to the transformational coefficient vectors, vectors of correlational variables and canonical dimensions were also used. The standards pertaining to these vectors were treated as a measure of canonical dimensions. The number of significant dimensions was determined with the Bartlett method (Bartlett, 1974), where all those linked canonical correlations varying from zero with an inference reliability of 0.95 were considered significant.

RESULTS

Based on obtained values of fundamental central and dispersive parameters of variables of sensomotor reactions of bilateral (transversal, parallel and diagonal) body parts. It can be confirmed that distribution of results in almost all variables does not significantly deviate from normal distribution. The results are displayed in Table 1. The dispersion of results in terms of arithmetic means indicates that derogation is lesser in all those variables of sensomotor reactions of bilateral body parts that tracked diagonal and transversal body reactions.

Table 1. The central and dispersive parameters of the sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts.

Variables:	XA	SIG	MIN	MAX
1. SRTNL	0.3083	0.0524	0.2237	0.3868
2. SRTND	0.3296	0.0676	0.2243	0.5103
3. SRTRL	0.2997	0.0573	0.1892	0.4054
4. SRTRD	0.2900	0.0737	0.1752	0.4776
5. SRPNL	0.3009	0.0571	0.2027	0.3971
6. SRPRL	0.3227	0.0497	0.2383	0.4205
7. SRPND	0.2939	0.0695	0.1425	0.3994
8. SRPRD	0.3048	0.0718	0.1612	0.4355
9. SRDNL	0.3004	0.0506	0.2149	0.3961
10.SRDRD	0.3180	0.0447	0.2359	0.4392
11.SRDND	0.2888	0.0460	0.1892	0.3621
12.SRDRL	0.2919	0.0603	0.1724	0.4124

Key: SRTNL-sensomotor reaction transversally left leg, SRTRL - sensomotor reaction transversally left arm, SRTND - sensomotor reaction transversally right leg, SRTRD - sensomotor reaction transversally right arm, SRPNL - sensomotor reaction parallel left leg,
SRPRL - sensomotor reaction parallel left arm,
SRPND - sensomotor reaction parallel right leg, SRPRD - sensomotor reaction parallel right arm, SRDNL - sensomotor reaction diagonal left leg, SRDRL - sensomotor reaction diagonal left arm, SRDND - sensomotor reaction diagonal right leg
XA - arithmetic mean
SIG - standard deviation
MIN - minimum
MAX - maximum

Cohesion of variables intended for measuring sensomotor reactions of bilateral (transversal, parallel and diagonal) body parts emit data that the area is homogeneous, what is an undoubted indicator of solid cohesion within the area. That is primarily in regard to sensomotor reactions that measured parallel and transversal structures, while the correlation coefficients within the context of sensomotor reactions of diagonal body parts are smaller (table 2).

Table 2. The matrix of correlational coefficients of the sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts

	1	2	3	4	5	6
1. SRTNL	1.00					
2. SRTND	.50	1.00				
3. SRTRL	.74	.44	1.00			
4. SRTRD	.51	.93	.51	1.00		
5. SRPNL	.59	.06	.31	.20	1.00	
6. SRPRL	.32	.22	.15	.26	.68	1.00
7. SRPND	39	.11	.64	.24	.51	.45
8. SRPRD	.58	.27	.62	.44	.63	.65
9. SRDNL	.75	.16	.49	.23	.65	.37
10. SRDRD	.48	.36	.26	.32	.31	.55
11. SRDND	.39	.18	.71	.30	.36	.14
12. SRDRL	.59	.29	.60	.48	.43	.36

	7	8	9	10	11	12
7. SRPND	1.00					
8. SRPRD	.84	1.00				
9. SRDNL	.37	.49	1.00			
10. SRDRD	.13	.41	.24	1.00		
11. SRDND	.66	.49	.17	.28	1.00	
12. SRDRL	.42	.65	.79	.20	.22	1.00

Key (see Table 1)

In general terms, the structure of the matrix of inter-correlation of variables indicates that the variables within the context of parallel and transversal body parts assemble within their groups, while it is somewhat weaker in the space of variables of diagonal body parts. A stronger cohesion in the space of parallel and transversal body parts, where the sensomotor reaction momentarily discriminates at the level of two cerebral processes that simultaneously occur in parallel and transversal body structures. While in the area of diagonal body parts, the sensomotor reaction discriminates in the moment at the level of two cerebral processes that occur in diagonal body structures. Thus, cerebral answers that simultaneously facilitate from the same stimulus represent the main reason of occurred connections within these spaces. Taking into consideration, the obtained results confirm the expected assumptions, what comes as a surprise, as these are low correlation coefficients within the group of variables of diagonal body part reactions. However, within the group of variables, which measured parallel, transversal and diagonal reactions, satisfactory and significant cohesion is discernable. A stronger cohesion is clearly visible within the group of variables that measured diagonal reactions with a group of variables that measured parallel and transversal reactions, as opposed to within their own variable group.

Significant cohesion within a group of bilateral body parts probably incurred as a result of simultaneous reactions of all set parts and mutual cerebral processes. The cohesion between the stated space probably incurred as a result of the process of coherence of separate and cooperative functions of the cerebral hemispheres, which can produce multivariant reactions. The results indicate that low cohesion within the context of diagonal reactions where initiating diagonal stimuli for certain body segments is dominant, undoubtedly indicating the importance of a clear preference for hemisphere lateralization. In addition, also present is a larger direct, autonomous and automatic possibility of utilizing parallel and transversal channels and good organization of active effectors (what is provoked by completing the task presented by the right lateral structures). This incurred as a consequence of life determination to right-handedness.

Canonical Relations of Sensomotor Reactions of Transversal and Parallel Body Parts

The canonical correlational analysis of the variable group of sensomotor reactions of transversal and parallel body parts indicates that out of four canonical roots, one is sufficient to explain the relations between the stated groupations (table 3). The canonical correlation of the first pair of canonical dimensions isolated from the variable groupation amounts to 0.92 with 85 % extracted joint variance. The obtained results indicate a significance level of P = 0.00.

Table 3. The canonical correlations, the roots of the canonical equation and tests of significance of canonical roots in areas of sensomotor reactions of parallel and transversal body parts

	C2	C	L	X2	DF	P
1	.8531	.9236	.0547	42.136	16	.0004
2	.5476	.7400	.3724	14.322	9	.1113
3	.1632	.4040	.8232	2.820	4	.5883
4	.0162	.1273	.9838	.237	1	.6264

Legend: C2 – eigenvalue; C – canonical correlation; L – Wilks lambda; X2 – Chi – square; DF – D. F.; P – sing. level

In the space of sensomotor reactions of transversal body parts the first canonical dimension is defined in the space of sensomotor reactions by the right arm and right leg, with a negative algebraic sign (table 4).

Table 4. The vectors of transformation into canonical variables (W) and canonical factors (F) are isolated in the area of sensomotor reactions of transversal and parallel and body parts

	W1	F1
1. SRTNL	1.04996	-0.46182
2. SRTRL	-1.73657 0.21883	
3. SRTND	-0.36976-0.13316	
4. SRTRD	1.65400	0.97839
5. SRPNL	0.87879	-1.06422
6. SRPRL	-0.69019 0.53783	
7. SRPND	-0.77681-0.96536	
8. SRPRD	1.24233	1.48241

Key (see Table 1), W1 - canonical variables, F1 - canonical factors

While it is in the area of sensomotor reactions of parallel body parts, the first canonical dimension is defined by the left and right arm and left and right leg with a negative algebraic sign.

Canonical Relations of Sensomotor Reactions of Parallel and Diagonal Body Parts

The canonical correlation analysis of the variable group of sensomotor reactions of parallel and diagonal body parts, indicates that out of four canonical roots, two are sufficient to explain the relations between the stated groupations (table 5). The canonical correlation of the first pair of canonical dimensions isolated from the variable groupation amounts to 0.93 with 86% extracted joint variance. The second canonical correlation that belongs to the second canonical factor has a somewhat lesser cohesion (0.85) with 72 % of joint variance. The second canonical correlation that belongs to the second canonical factor has a somewhat lesser cohesion (0.78) with 61% of joint variance, at a significance level of P = 0.01.

Table 5. Canonical correlations, roots of the canonical equation and significance tests of canonical roots in the area of sensomotor reactions of parallel and diagonal body parts

	C2	C	L	X2	DF	P
1	.8647	.9299	.0311	50.329	16	.0000
2	.6104	.7813	.2298	21.325	9	.0113
3	.3701	.6084	.5897	7.657	4	.1050
4	.0637	.2524	.9363	.955	1	.3285

Legend (see Table 3)

The first canonical dimension in the area of sensomotor reactions of parallel body parts is defined by the left and right leg, with a negative algebraic sign. In the area of sensomotor reactions with diagonal body parts, the first canonical dimension is defined by the left leg and right hand, with a negative algebraic sign (table 6).

Table 6. The vectors of transformation into canonical variables (W) and canonical factors (F) are isolated in the area of sensomotor reactions of parallel and diagonal body parts

	W1	W2	F1	F2
1. SRPNL	0.8669	-0.2398	0.9721	0.6089
2. SRPRL	-0.6211	0.2779	0.3713	-1.3121
3. SRPND	1.2948	0.1467	-0.5445	-1.2445
4. SRPRD	-1.3128	-1.1301	-0.4471	1.3262
5. SRDNL	0.9666	-0.0183	1.3074	0.1694
6. SRDRL	-0.7120	-0.1961	0.4271	-0.6343
7. SRDND	0.7075	-0.4368	-0.4251	-0.4980
8. SRDRD	-0.9374	-0.7126	-0.9739	0.5800

Key (see Table 1, 4)

The second canonical dimension in the area of sensomotor reactions of parallel body parts is defined by all body parts, from which the left arm and right leg have a negative algebraic sign.

In the area of sensomotor reactions with diagonal body parts, significant projections towards the second canonical dimension has reactions with the right arm and left arm, and left arm and left leg with a negative algebraic sign.

Canonical Relations of Sensomotor Reactions of Diagonal and Transversal Body Parts

The canonical correlation analysis of the variable group of sensomotor reactions of transversal and parallel body parts, indicates that out of four canonical roots, two are sufficient to explain the relations between the stated groupations (table 7). The canonical correlation of the first pair of canonical dimensions isolated from the variable group amounts to 0.95 with 90% of extracted joint variance. Obtained results display a significance level of P = 0.00. The second canonical dimension that belongs to the second factor has a somewhat weaker cohesion (0.85) with 72% of joint variance on a significance level of P = 0.01.

Table 7. Canonical correlations, roots of canonical equation and significance tests of canonical roots in the area of sensomotor reactions of diagonal and transversal body parts

	C2	C	L	X2	DF	P
1	.9032	.9504	.0199	56.783	16	.0000
2	.7217	.8495	.2058	22.920	9	.0064
3	.2043	.4520	.7397	4.372	4	.3580
4	.0704	.2653	.9296	1.059	1	.3035

Key (see Table 3)

In the area of sensomotor reactions of diagonal body parts the first canonical dimension is defined by the sensomotor reactions of all body parts, from which the left leg and right leg have a negative algebraic sign. In the area of sensomotor reactions with transversal body parts, the first canonical dimension is defined by the right arm and right leg and left arm with a negative algebraic sign (table 8).

Table 8. Vectors of transformation in canonical variables (W) and canonical factors (F) isolated in the area of sensomotor reactions of diagonal and transversal body parts

	W1	W2	F1	F2
1. SRDNL	-0.7553	1.1590	-0.7987	0.3479
2. SRDRL	-0.2505	0.2996	0.6336	-0.7591
3. SRDND	0.6720	0.1131	-0.7076	-0.3939
4. SRDRD	1.0857	-0.4315	1.0884	0.3490
5. SRTNL	-0.6274	1.2639	0.3531	0.5082
6. SRTRL	-1.2855	-0.0988	-0.5221	-2.3753
7. SRTND	0.9747	-0.2100	-0.9914	-0.6377
8. SRTRD	1.5125	-0.2313	1.5304	1.8361

Key (see Table 1, 4)

The second canonical dimension in the area of sensomotor reactions of diagonal body parts is defined only by the left arm. In the area of sensomotor reactions of transversal body parts, reactions of the right arm and left leg and left arm and right leg with a negative algebraic sign have significant projections on the second canonical dimension. The obtained canonical dimensions undoubtedly indicate the significance of the process of coherence of separate and cooperative functions of bilateral cerebral determinations that can produce clearly differentiated sensomotor reactions of bilateral body parts. In addition to certain similarities within sensomotor reactions of bilateral body parts, a clear preference of transversal and parallel body parts is manifest as well as the prevalence of upper limbs. Starting out from the realization that the sensory receptor receives stimulus and conveys data in a minimal time interval between sequential answers, only a part of that time goes towards refractor time in central processes. The operator spends this time on deciding and organizing answers, which will immediately upon installing an adequate network be carried out without further participation of the willing operation. Actually, from the moment the answer is initiated, the operator can no longer stop it. The efficiency of that reaction time, or rather, the time of initiating an answer, is such that the time lag that significantly contributes towards the duration of creating an efferent signal and its transference to the effector is logged in the system. According to the obtained correlation coefficients, it seems that the mechanism of commissural connections between the cerebrum hemisphere cortex and the contractions of the agonist, antagonist and synergic tonus regulation are more pronounced within diagonal body parts, than within transversal and parallel body where the process is more effective. Thus, for the sensomotor reactions of bilateral body parts, for whose variability and covariability the responsibility is borne by a mechanism for regulation of stimuli that are led away from the sensor by way of sensory afferent neurons into adequate centres, where transformation occurs as well as transposition to efferent neurons. Stimuli that come to the integration effector of bilateral reactions form ideomotorical structures and control of the processes of referentation and alternative muscle innervation. Thus, it is logical that these processes comprise the basis for obtaining canonical correlations to which sensomotor reactions of bilateral body parts contribute the most. The stated processes of impulse transmission through afferent and efferent channels represents the functional basis for obtaining correlative relations within the field of sensomotor reactions of bilateral body parts.

DISCUSSION

The research was carried out with the goal to affirm a part of the entire variability separated by the sensomotor reactions of bilateral (transversal, parallel, diagonal) body parts. The research study was conducted on a sample of 20 subjects, of male gender, ranging from 20 to 22 years of age. The process of collecting data and setting parameters was conducted by using an instrument called the KINESIOMETER (M. Dodig, 1987.), hooked up to an electronic computer, with an adequate periphery, with application of program support for analogue – digital conversion in the programming language SIMON'S BASIC, which enabled an analogue – digital conversion of results. Data about sensomotor reactions of bilateral (transversal, parallel, diagonal) body parts was obtained through measuring. The relations between the velocity of bilateral body parts were analysed and affirmed via the technique of canonical correlational analysis (Coolly and Lohnes, 1971). Based on maximum cohesion between the pair of linear functions two groups of variables that are in the are of sensomotor reactions of transversal and parallel body parts, one characteristic canonical root was extracted which explained 85% of the joint variance. Two pairs of characteristic canonical roots were extracted in the area of parallel lateralization, the first explaining 90%, the second 72% of joint variance. In the area of sensomotor reactions of diagonal and transversal and parallel body parts, two pairs of characteristic canonical roots were extracted, the first explaining 86%, the second 61% of joint variance. The obtained results indicate a topological and functional dependency of sensomotor reactions of bilateral (transversal, parallel, and parallel) body parts. An efficiency of functioning of the emission signal speed and the speed of the synaptic transmission (the number of synaptic ties and flow through synaptic barriers), efficient functioning of commissural relations between the hemispheres and the efficiency of afferent and efferent paths directed towards sensomotor reactions of bilateral (transversal, parallel, and diagonal) body parts can probably be found at the basis of these indicators. Thus, a mechanism for bilateral impulse regulation, forming ideomotor structures and the control of the reeferentation process and alternative muscle innervation, is responsible for the variability and co-variability of sensomotor reactions of bilateral body parts.

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