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Learning and Thinking Styles Based on Whole Brain Theory in Relation to Sensory-Motor Integration

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Abstract The study aims to explore learning and thinking styles based on Whole Brain Theory; and their relationship with sensory-motor integration. It also explores the correlations between variables. Two tests were used to explore the correlations between the two variables (learning and thinking styles based on Whole Brain Theory test and sensory-motor integration test). Tests were administered to discover whether the variables differ according to gender and age groups. Validity and reliability of the tests were insured. The study was conducted based on a stratified random (cluster) sample of (753) male and female students. The participants are (12-16) years old, enrolled in 13 public schools (7 male and 6 female schools) at Irbid first directorate. The study reveals significant correlations between both (Q_D i) and (Q_C ii) with sensory-motor integration test due to gender differences in favour of females.

Keywords Hemispheres, Brain, Sensory-Motor Integration, Learning and Thinking Styles

1. Introduction

People tend to rely on one side of the brain more than the other in information processing. This reliance is referred to as dominancy which may appear among people in the style adopted in the process of learning and thinking. John Jackson invents hemispheric dominancy as he proposes the idea of the leading hemispheres of which brain dominance is derived. Different researchers verify the importance of this phenomenon in the process of thinking and learning, through studying correlations between thinking and learning styles with hemispheres functions[1].

The right hemisphere controls sensory-motor activities of the left side of the body, while the right side activities are controlled mainly by the left hemisphere. Therefore the right hand, leg or ear stimuli are processed mainly in the left hemisphere whereas the left hand, leg or ear stimuli are processed in the right hemisphere[2]. Eyes are controlled in a more complex way. The visual field is divided. Each eye transfers information to both hemispheres. In this process, the left eye field vision is recognized in the right hemisphere, and the right eye field vision is recognized in the left hemisphere.[3] Facial muscles are likely to be the first recalled to function. Then follows the muscles of the upper part of the body, and lower part muscles respectively. Finally, muscles of the whole body are triggered[4].

Whole brain theory offers an approach for understanding brain functions through Four Quadrant Model. The model presents four modes of learning and thinking based on whole-brain theory. The model focuses on three basic ideas. First, styles are not featured as good or bad, nor as right or wrong. Second, the style shows a preference for mental activity which is quite different from the efficiency of performing that activity. Third, styles tend to be constant over time. Herrmann[5] divides these styles as Left Mode Thinking Processes which is divided into two parts. First, Upper Left Quadrant or what is referred to as Q_A. This style features the person preference of activities such as analyzing, dissecting, figuring out, solving problems logically, and getting facts. In making decisions, the person relies on logic based on certain assumptions, combined with the ability to perceive, verbalize, and express things precisely. Second, the Lower Left Quadrant is symbolized by (Q_B). A Q_B features a person who has rules, adheres to them and to what has worked before. However; he fights progress and does not accept the change. His efficiency has to do with making sure things are done on time and in a correct manner. Herrmann further focuses on one thing at a time then moves to the other. Moreover his interest is always focused on answers.

Right Mode Thinking processes include two parts. First, the Lower Right Quadrant, which is referred to as Q_C. A Q_C, is featured as a sponge that sops experience. As Q_A, Q_C is preoccupied with facts associated with emotional trends, the person of this type recognizes when the mood change occurs then he responds to it calmly. He recognizes experience as a fact. There is no time for logic or for theoretical perspective for him. Second, the Upper Right Quadrant, referred to as Q_D, features an ambiguous person. The speech of such an ambiguous person relies on metaphors

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without providing translations of how these metaphors help in clarifying what he says[5].

From a functional view, some obvious differences between the two hemispheres are related to the motor control. The right hemisphere controls the movement of the left part of the body, and the left hemisphere controls the movements of the right part of the body[6],[7]. Few studies correlate the right hemisphere with motor skills. While some researchers correlate motor skills with the left hemisphere, others tend to correlate the two hemispheres with motor skills. The right hemisphere is considered an important factor in determining the right hand skill for who uses it for major motor skills, while spatial and touch skills are more correlated with the left hemisphere[8].

Sensory - Motor Integration is characterized by the integration of activities, and it is controlled by different parts (limbs) and senses of the body especially the vision. It is the ability to control one or more parts of the body when used in complex movements to integrate parts movements in doing a motor activity characterized by smoothness and success. It may also include some sort of integration between body parts especially the sense of vision. A clear example of such integration is what happens between the hand and eye or between the leg and eye[9].

When considering senses roles in learning, we should not be concerned with the way these roles help children to learn skills and information. However, it is preferable to focus on the developmental impact on the child's ability to perform specific tasks, as well as, the impact of classroom activities on the development and integration of sensors. Sensory and motor systems form the basis of subsequent development of both typical verbal and abstract thinking. Reading and writing requires a complex coordination between these two systems. Children who do not achieve sufficient integration between the two systems face motor and sensory learning difficulties[10],[11]. In schools, specialists often overlook the sense of movement as a component of learning; it is usually beyond cognition. When one is not sure of a word spelling, he relies upon the sense of movement to guide his hand (although one may also rely on visual checking to see if the word looks correct). When one uses hands to explain something, he uses thinking based on a sense of movement and verbal thinking[12].

Teachers in primary education direct children not to move in class, and not to move their eyes away from the blackboard. The teachers ignore the fact that sight is basically associated with the movement, and that the eye is not fully adapted with collagen fibers. Although eye movement appears simple or physically small, it has a large impact on the way in which a child accesses knowledge and cognition. Movement awakes many mental abilities and energizes them. It also integrates new information and experience in the neural networks and firms it. Additionally it is vital for every movement that reflects individual learning and understanding of self[13]. Intelligence exists in the cells distributed throughout the body in addition to the brain[14]. For the purpose of this research, there are three basic points according to Ratey[15] that explain the correlation:

• Movement is essential for the existence of the brain in particular. In fact organism that moves from one place to another is in need for the brain.

• The frontal half of the brain is specialized in organizing physical and mental activities; because "higher" brain functions originated from such movements and it continues to depend on them.

• Movement is crucial for each brain function including remembering, emotions, language and learning.

Physiological gender differences lead to performance variability in general. According to Sylwester and Jensen, there are other functional differences that affect learners such as vision, touch, mobility and activity. While Males outperform in distance vision and bright light vision, females outperform in side vision and night vision. Also, females are more sensitive to red color degrees of the spectrum. They outperform visual memory, awareness of facial expressions and context significance. In addition, they express a greater ability to recognize faces and remember names. In several studies women are able to save visual random unconnected data in the memory more than men do.

As for touch, female's sense of touch is strong and widespread. Their pain reaction is faster and more intense than males. Their fingers and hands sensitivity level outperforms its counterpart among males. As a result, they excel in performing new hand movements, having a clear skill in moving their fingers and enduring pain more than male do. However, males' reaction to high temperatures is faster.

Concerning mobility and activity, male children tend to play with objects and respond to them more than females do. Males choice of direction is contrary to females, i.e. when right handed males move to pick something from a table, they often turn around to the right direction. However, right handed females often move to the left direction. Studies show that females are more capable than males in fine motor skills, one of which is sensory-motor integration. And if this is the case, does that mean that females use the right hemisphere in the process of thinking and learning more than males do? Results may not be clear because studies results concerned with the differences between males and females use of the two hemispheres in the process of thinking and learning were not firm, and not monotonous[16].

Garicia[17] refers to a number of skills where one gender outperforms the other. Females outperform males in the skills of finger unity and harmony movements, computer and mathematics tests, remembering objects in a particular order, remembering road signs, using verbal memory, expression fluency, estimating depth, speed, cognitive abilities, understanding body language and facial expressions. While males, on their part, outperform on the following tasks or skills: aiming, using vocabulary, focusing for long periods of time, mathematical thinking and the ability to solve problems, noticing spatial properties of places, verbal intelligence, and the formation of habits and persisting on them.

Psychologists argue about the age in which brain specialization develops and grows: At birth or later?[18].

Some researchers, advocates of the evolutionary theory, believe that myelin formation corresponds with childhood development which Piaget classified[19] into:

Sensory-motor stage (0-2 years): In this stage, the child uses motor activity with the surrounding, forms ideas about how to deal with it. At this stage, myelin deposits on motor and visual systems in the brain.

Pre-operational stage (2-7 years): At this stage, a child cannot think of abstract things. He/she needs a physical environment for learning. At this stage, myelin deposits on the brain language regions.

Concrete operational stage (7-11 years): The child can understand some abstract issues and solve some problems, but he learns through physical and working environments. At this stage, myelin deposits on thinking and cognition regions.

Formal operational stage (11-15 years): At this stage a teenage can perform abstract thinking. His recognition level becomes as adults recognition. At this stage, myelin deposits on higher-order thinking, problem-solving and decision making regions of the brain.

It seems that the evolutionary part of learning and thinking styles based on the two hemispheres and its relation with sensory-motor integration studies are rare until now. If we assume that there is a difference in gender in the way of learning and thinking, considering the physiological brain difference between them. Fulbright[20] in this respect conducts a study to examine the relationship between Reported Cognitive Mode as a sign of hemisphericity and motor performance in light of different genders. The sample consists of 125 students from secondary schools and colleges in USA. The study utilizes several tests: Style of Learning and Thinking test (SOLAT B), motor performance test and handedness test. The results reveal that the right learning and thinking style may not significantly affect the motor performance. It also appears that the left hemisphere may significantly affect negatively motor performance. The study also supports the view that males are more handed than females.

Webb[21] evaluates an instructional drawing program of sixth grade. The program uses techniques designed to stimulate the right cerebral hemisphere. In order to determine the effect of instruction on still life drawing, and human figure drawing, using two groups from the University of South Carolina: An experimental group (55 students) enrolled in an art curriculum, and a control group (55 students) from courses of music, typing and physical education. No significant effects were observed of the variables on the right cerebral hemisphere.

Another study of Hall & Lee[22] examines the gender differences in motor performance of (540) prepubescent boys and girls in 3rd, 4th and 5th grades. The sample participates in coeducational physical education program in Louisiana, USA. They are tested with American Association for Health-Physical Education and Recreation (AAHPER) Youth Fitness Test. scorings are analysed to find the differences. The results indicate that females at prepubescent ages may be expected to perform at similar levels to boys of the same age on most test items. As for 5th grade females performance is better than males' of the same age and of 3rd and 4th grades.

Albert[23] study focuses on the measurement of brain dominance and its relationship with physical integration and gender for 191 high school students in Michigan, USA. Hemispheric orientation is measured using Human Information Processing Survey. It consists of 40 self-determined items determining the dominant processing pattern among the participants left, right, or integrative. Participants' profile data is also used in the study. All correlations are found not to be significantly related at (α = 0.05).

Vlachos & Karapetsas[24] assess the differences between left-and right-handed children on sensory-motor organizatio n variable, by copying of a complex figure. The sample consists of 420 right-handed children and 389 left-handed children aged 5.5 to 12.5 years, from Greece. Analysis shows a statistical significance in the performance of left-handed children compared to right-handed children, and those who use both hands in favour of males aged 7.5 to 9.5. It also appears that left-handed male student's performance is equal to female's performance using both hands at ages from 9.5 to 12.5 years. These differences are attributed to neuropsychological strategies or functional differences between genders and right or left-handed children.

Al-Sheikh[8] conducts a study to examine the relationship between the two hemispheres that supports sensory-motor integration among 250 right-handed students enrolled in 6th grade. The participants took hemisphericity test and sensory-motor integration test. The results indicate significant differences in using left or right or the two hemispheres, in favour of the two hemispheres together. Results also refer to a negative correlation between using the two hemispheres with sensory-motor integration. Males appear to outperform females in using right hemisphere, but they equalize with them in using left hemisphere and both hemispheres together.

Davies & Rose[25] study specifies the developmental trends in motor performance and coordination across three stages of development: Pre-pubertal, puberty, and post puberty of both genders. Their sample consists of 60 participants (30 males, 30 females) from New York, USA. Participants are assessed in 13 motor tasks. Analysis of variance and covariance reveal that motor performance improves significantly throughout adolescence in both genders in favours of males. Female's performance is less than males after puberty. Further, no evidence is found regarding lack of motor coordination at puberty for both genders.

Lehman, Olson, Aquilino, & Hall[26] conducted a study that examines the test of auditory and visual performance, brain functions (abilities) and its correlation with age and gender. Twenty seven students from first grade and kindergarten, 21 students from third grade, and 25 from 5th and 6th grades from Virginia, USA participate in the study. The researchers administer two tests: Visual and audio test; and mental abilities test. Scorings of audio and visual performance test reveal that performance improves with aging. Also, an apparent effect of gender emerges in the visual test in favour of males in kindergarten, 1st, and 3rd. However, it is in favour of females in 5th and 6th grades.

Lissek et al[27] compare brain activation patterns in men and women during performing fine motor tasks in order to investigate influence of motor task complexity upon asymmetries of hemispheric recruitment. The sample consists of 33 right-handed participants (17 males, 16 females) from Germany. Self-paced finger-tapping task comprising of three conditions of increasing complexity with both the dominant and non-dominant hand is administered. Results demonstrate significant gender differences in activation patterns. Women activation is significantly larger in cortical areas, but men activation is significantly larger in sub cortical areas. The researchers observe differences between genders reflected in activation area of psychomotor voluntary skills of the cortical and subcortical areas, which is related to motor sequence processing. In addition, the researchers find differences in hemispheric recruitment. Results show that gender does not affect performance, but it affects the place and the way the activation happens.

Larson and others[28] study aims to discuss the developmental status of the motor system. They examine four summary variables: Gaits and stations, overflow, dysrythmia, and timed movements. The sample consists of 144 children (72 boys, 72 girls aged between 7-14 years) from Baltimore, USA. The Physical and Neurological Examination for Subtle Signs was administered. They observe significant gender effects for some subtle signs (involuntary movements), gaits and stations, and timed patterned movements. In all instances, girls show fewer subtle signs and they are faster and more proficient than boys. Significant age-related changes are observed for some subtle signs (dysrythmia, overflow and timed movements). By age 7, it reaches “adult” level in typically developing children. Motor development appears to follow a different developmental course in girls than in boys.

Ohtoshi, Muraki, & Takada[29] conducted a study to determine the relationship between unbuttoning and buttoning ability with age and gender difference. The sample consists of 144 Japanese children (63 males, 81 females aged 36-83 months and 14 youths pre-puberty). Then participants were divided into four groups according to age. Group 1 involves every subject joins to nursery school or kindergarten. On the basis of Montessori education system, unbuttoning and buttoning are performed. The instructions were given to all participants to do the same task the same way. The results show that as age increases, less time is required to decode and button. In fact, time is required for unbuttoning and buttoning. Unbuttoning required time decreases to age 4, and buttoning to age 5. There are no significant differences between males and females; except in unbuttoning on age 3, in favour of females. The study recommends that more attention is required on children unbuttoning and buttoning, since this may be a simple and easy clinical evaluation method.

Clay et al.[30] conduct a study to evaluate the relationship between sensory and cognitive decline, particularly with respect to speed of processing, in the light of age variable. The study sample consists of 842 U.S participants. Their main age is 73 years. The results indicate that sensory functions are partly dependent on aging and processing speed.

Reviewing the literature on sensory-motor integration and its relationship with age and gender shows motor performance improves with age for both genders as in Davies & Rose,[25]; Lehman, Olsen, Aquilino & Hall,[26]; Larson et al,[28].; Clay et all,[30]. Some studies reaffirm a significant development of females over males as in Hall & Lee[22]; Lehman, Olsen Aquilino, Hall,[26]; Ohtoshi, Muraki & Takada,[29]., or significant development of males over females as in Davies & Rose,[25]. Other studies indicate that females’ movement is less, but they are faster and their tasks are mastered as in Larson et al,[28].

Literature review on learning and thinking based on hemisphericity and its relation sensory-motor integration reveal that there is no correlation between the right hemisphere with motor performance as in Fulbright[20]; Webb[21]. However, left hemisphere has a significant negative effect on motor performance as in Fulbright[20]. Some studies prove that there is no correlation between hemispheres dominancy and motor performance as in Albert[23]; Sheikh[8] Other studies determine most brain activation areas, females' cortical area, males' subcortical area are activated for voluntary motor tasks. Differences are not in performance, but in the place and manner of activation[27].

Results contradict each other in determining the place effect of the dynamic movement in the two hemispheres. They also differ in defining the role of gender in motor development. This study aims to fill the gap of this literature, to detect the specialized quadrant in motor performance, and to find if it varies according to age and gender.

1.1. Statement of the Problem

Most named mental functions and processes such as voluntary movement and handedness are in fact the product of complex brain interactions. They are also the basis of the relationship between human behavior and brain functions related to left and right hemispheres. To force students to sit down in silence is considered worst-case scenario for the brain, whereas the best-case scenario is the active participation of the body. There is a close relationship between the brain and the body. The study argues upon the correlation type between the two brains and their quadrants. Is the correlation type a replacement or integration? They also argue upon the correlation of the right brain and its quadrants, or the left brain and its quadrants or correlation of both brains with motor activities.

The current study is an attempt to explore students' preferences in using one half of the brain over the other, and the brains correlation level with sensory motor integration. In addition, the study deals with four quadrants correlation with sensory-motor integration, in terms of age evolutionary age groups (12- 13, 14-15, 16-17) years and of both genders. The current study will attempt to answer the following question:

What is the correlation between learning and thinking styles based on whole-brain theory with sensory-motor integration test? Are there significant differences at ($\alpha = 0.05$) in the correlations between learning and thinking styles with whole-brain theory due to the gender and age group?

1.2. Significance of the Study

One additional aspect of learning based on a sense of movement, is the role played by the movement in some individuals thinking. It is very difficult for some people to think while they are sitting without movement. They need to walk or move in some way to be able to think. It is obvious that there might be a class full of students who think while moving. Although it is important to provide a quiet space for students whose thinking might be distracted with sensory-motor stimulus, it is also important to provide special environment to students who learn better if they are given the chance to move.

Research on learning and thinking styles based on the whole-brain theory and its relationship with sensory-motor integration and hemisphericity usage add an important dimension to the educational and developmental procedures. This in turn, adds an important dimension that focuses on the type of relationship between brain chemistry, motor development and academic performance. Identifying the differences between males and females in preference of using brain quadrants and the sensory-motor integration of age group (12-16 years) may contribute in both: Finding causes of these differences, and in developing proper educational and psychological programs considering the relationship between motor development and other aspects of growth as an important integrated relationship.

1.3. Definitions of Terms

Learning style based on whole-brain theory means individual usage of one quadrant of the brain (learning style: Q_A; Q_B; Q_C; Q_D) in mental processes. It is measured by individuals' performance on learning and thinking styles test.

Sensory-motor integration deals with students scoring obtained on the sensory-motor integration test according to the testing manual of the test, which requires using preferred hand in drawing lines and shapes under specific conditions (the right hand in the current study).

1.4. Variables of the Study

Independent variables:

1. Age groups (12_13, 14_15, 16_17) years.
2. Gender.

Dependent variables:

1. Learning and thinking styles based on whole-brain theory Q_A, Q_B, Q_C, and Q_D.

2- Sensory-motor integration.

1.5. Limitation of the Study

The study is limited to male and female students of(12_13, 14_15, 16_17) years, from Irbid First Directorate primary schools. It is limited on psychometric characteristics of learning and thinking styles test based on whole-brain theory. It is also limited with the type of data analysis. Therefore the results of the study are valid for generalization upon its community and similar communities.

2. Methods

2.1. Participants

The population consists of all 27816 students in age group (12-16) years, enrolled in 7th, 9th and 10th grade of public schools of Irbid First Education Directorate. Out of this population, a randomly stratified cluster sample of 753 students from 7 male and 6 female schools was selected.

Table 1. this table presents the sample distribution by gender and age group

Gender	Statistics	Age			Total
		13-12	**15-14**	**17-16**	
Males	No	123	132	115	370
	Percentage %	16.3	17.5	15.3	49.1
Females	No	130	124	129	383
	Percentage %	17.3	16.5	17.1	50.9
Total	No	253	256	244	753
	Percentage %	33.6	34.0	32.4	100.0

Learning and thinking styles based on whole-brain theory test are based on the Herrmann Brain Dominance Instrument "HBDI". HBDI is composed of 120 items based on whole-brain theory. Chi revises the test and adapts it to the Chinese. 60 items were divided to describe the learning activities that Chinese students might prefer while learning into four brain quadrants (15 items each). Herrmann[5] divides the test into four styles:

1). Q_A: learning and thinking style preferred by students featuring A quadrant "upper-right brain".

2). Q_B: learning and thinking style preferred by students featuring B quadrant "lower-left brain".

3). Q_C learning and thinking style preferred by students featuring C quadrant "lower-right brain"

4). Q_D: learning and thinking style preferred by students featuring D quadrant "upper-right brain".

2.2. Validity and Reliability

Eight professors in the Department of Counselling & Educational Psychology at Yarmouk University verify the logical validity of study items before administering it. They agree upon its validity, which is verified by administering the test on three classes (students ages 12, 14, 16 and no.192) from the whole population, one class for each age group. The stability sample consists of 192 students. The retest is processed two weeks apart. Reliability on Pearson correlation coefficient scores (0.860) on the overall test. The scores on separate dimensions are as follows: (Q_A: .7360; Q_B: .7000; Q_C: .7760; Q_D: .7940). Internal consistency (Cronbach's Alpha) scores 0.872 on the overall test, and for the dimensions it scores (Q_A: 0.744 Q_B: 0.720; Q_C: 0.676; Q_D: 0.773) the items answered by students of each quadrant were classifies as: (Little 0- 4.99), (average 5- 9.99) and (Large 10-15).

Al-Waqfi[31] develops the sensory motor integration test depending on similar tests. The test evaluates a student's ability to integrate sensory motor performance in terms of drawing geometrical shapes that ranges in its difficulty and complexity. Studies indicate that this ability is correlated with child's readiness for school learning, especially in early school years that affect later academic performance. The test consists of 24 sequential and consistent forms that assess students' sensory motor integration of children's between 6.5- 16.5 years. The test starts with a series of geometric shapes young children may draw. He starts with simple shapes as vertical, horizontal, diagonal or curved lines, to more complicated and complex shapes that correspond with children's age development.

2.3. Validity and Reliability

Al-Waqfi[31] calculates test validity through discriminating validity of performance medians between age groups in both experimental and controlled groups. In the experimental group a statistically significant effect is apparent through ANOVA analysis (P = 45.11, alpha> .0001) of age on performance. Using Scheffe test proves the existence of a statistical difference between averages of age groups. Concurrent validity of student's performance on the test and on two other tests (visual and audio analysis) administrated on the same experimental group of which sensory motor integration. Correlation coefficient is 0.78 between sensory motor integration and visual analysis test. It reaches 0.68 between sensory motor integration and audio analysis test. Both are statistically significant and relatively high.

Eight professors in the Department of Counselling & Educational Psychology at Yarmouk University verify the logical validity of the items before administering it. They agree upon its validity for age group, and the appropriateness of the shapes for measurement.

Test reliability is tested through administering it on three classes. Al-Waqfi[31] calculates test reliability using two analyses. First, using split-half reliability (odd-pair) where correlations are calculated on by Spearman equation. The correlations reach 0.91 for the revised version. Second, Cronbach's alpha value of alpha reaches 0.92 for the experimental form and 0.90 for the revised form.

Sensory motor integration test reliability is established through administering it on 12, 14, and 16 years old students in three classes where each age group is enrolled in a different class of the total population. One hundred ninety two students compose the reliability sample. The students were retested two weeks apart. Reliability coefficient with Pearson correlation equation was calculates and it scores 0.80. As for internal consistency Cronbach coefficient was calculates based on the pilot sample (n= 192), and it scores 0.75.

The student's response was considered correct if he/she is able to draw a correct shape; and it is considered wrong if none of the correction criteria is applied on what he draws. The marks were given upon level of difficulty, complexity and age group that equalizes the right response of the item. Then total score was determined according to correct answers, minimum score = zero, and maximum = 50. Scoring can be calculated in several ways, t-score used in this study based on standard distribution average 50 and standard deviation 10[31] Calculating t-score[32]: $T = 50 + 10Z$.

2.4. Procedures of the Study

Obtain an official statement from the Ministry of Education to administrate the tests on the sample. Learning and thinking styles based on whole-brain theory takes 20 minutes and sensory motor integration takes 20 minutes, too.

2.5. Statistical Analysis

The correlation coefficients were calculated between learning and thinking styles based on whole-brain theory and sensory motor integration using Pearson coefficient, and then calculates differences of the tests by v-coefficient.

2.6. Results

Table 2. Linear correlation coefficients between sensory motor integration test and learning and thinking styles based on whole-brain theory

Thinking & Learning style	Pearson correlation with sensory motor integration
Q_A	0.01
Q_B	0.00
Q_C	0.03
Q_D	0.04

The study attempts to answer the following question: What is the correlation between learning and thinking styles based on whole-brain theory with sensory-motor integration test? Are there significant differences at ($\alpha = 0.05$) in the correlations between learning and thinking styles with whole-brain theory due to the gender and age group?

Pearson correlation coefficients were used to determine students' level of using each learning style correlated with sensory motor integration. Review Table 2.

We recognize from table 2 a positive significant correlation at ($\alpha = 0.05$) between each learning and thinking style with sensory motor integration.

Then differences between correlation coefficients of learning and thinking styles and sensory motor integration according to gender variable were calculated. The Pearson correlation coefficient between the degree of which students use each style of learning and thinking on one side and the degree of sensory motor integration on the other upon gender difference. Then, correlations were converted to z-Fisher values, and uses the difference between coefficients correlation of two independent samples (Z = (Z1-Z2)/ $\sqrt{\frac{1}{(n_1-3)}+\frac{1}{(n_2-3)}}$) z-Fisher.

Table 3. difference of coefficients of both sensory motor integration test and learning styles based on whole-brain theory in terms of gender variable

Thinking & Learning style	Gender	Correlation coefficient	No.	Z	Statistical Significance
Q_A	Males	-0.080	370	1.625	0.052
	Females	0.144	383		
Q_B	Males	-0.106	370	0.566	0.286
	Females	0.173	383		
Q_C	Males	-0.049	370	4.823	0.000
	Females	0.136	383		
Q_D	Males	-0.049	370	4.90	0.000
	Females	0.152	383		

Table 3 reveals a statistical difference at (α = 0.05) in the correlation between each learning styles (Q_C and Q_D) on one hand and between sensory motor integration test on the other hand due to gender difference in favour of females. This means that linear correlation between each of learning and thinking styles (Q_C, Q_D) with sensory motor integration performance is significantly higher than males.

Table 3 shows no significant difference at (α = 0.05) in the correlation between learning styles (Q_B, Q_A) with sensory motor integration test due to the gender difference.

The Pearson correlation coefficient between the degree of students' usage of learning styles and the degree of sensory motor integration according to different age groups was used. Then it was converted into Z-Fisher values. As for V coefficients, they are shown in table 4.

Table 4. V correlation statistical differences between sensory motor integration tests with learning style based on whole-brain theory according age group

Thinking & Learning style	Age group	Correlation coefficient	No.	Statistics V
Q_A	**13—12**	0.05	253	1.73
	15—14	-0.06	256	
	17—16	0.02	244	
Q_B	**13—12**	0.04	253	0.79
	15—14	-0.01	256	
	17—16	-0.04	244	
Q_C	**13—12**	0.06	253	0.64
	15—14	0.03	256	
	17—16	-0.01	244	
Q_D	**13—12**	0.07	253	1.35
	15—14	-0.02	256	
	17—16	0.06	244	

Table 4: V correlation statistical differences between sensory motor integration tests with learning style based on whole-brain theory according age group.

Table 4 shows no statistically significant differences at (0.05 = α) in correlation between each of learning and thinking styles (Q_A, Q_B, Q_C and Q_D) with sensory motor integration test due to different age groups because V coefficients are less than the tabular value of Chi square.

2.7. Discussion

The results reveal the existence of a significant statistical difference at (α = 0.50) in the correlations between learning and thinking styles in quadrant D and C with sensory motor integration test due to gender differences in favour of females compared to males.

Motor is very important for any brain function, including memory, emotion, learning and language. Our "upper" brain functions grow from motor and still depend on it. Motor function is important for some forms of cognition as the physical movement. As the study claims that if we understand the motor in a better way then we can also understand ideas better[33].

Preference to use the right hemisphere (Q_C and Q_D) of the brain in learning and thinking may be interpreted as a sign of supporting that "one hemisphere is more active than the other". What makes an individual dependent on one hemisphere in sensory motor integration is clearer than him relying on the other. Preference in using one hemisphere over the other depends on the task or activity to be accomplished, whether it is linguistic or physical[34]

Most artistic and creative activities require activation of the right hemisphere[18]

Q_C individuals prefer to wear comfortable clothing for movement. Also, they do not like clothing that causes physical inconvenient. Further, they care about clothing colours that has distinctive emotional impact on the self and others. In addition, they look like Q_D but they are very personal in their clothes[5].

Motor skills that correlate with power, speed, and using tools, are more correlated with the left hemisphere, while motor skills related with vacancy, touch, and fine motor skills are correlated with right hemisphere better. Students depending on the right hemisphere are better in engineering drawing in both genders, more than left hemisphere students[35].

Unlike the left hemisphere, the right hemisphere has a larger role than in determining the skill of moving objects fast from the right side to left using the right hand, and from the left side to the right using the left hand[36]. Participants of the current study are right handed. The result is that the right hemisphere is dominating sensory motor integration. Hand preference is neither necessarily a sign of hemisphericity dominance nor a necessary correlation of dominancy[37].

As we notice that there is no absolute hemisphericity dominancy because every hemisphere plays its own role in different behaviours[6],[38],[39].

Interpreting the correlation between handedness and brain dominance of one hemisphere is not easy; rather it is difficult to identify the causes of dominancy. In the light of such a difficulty, dominancy does not work according to the law of all or nothing. As some people use both hands with the same efficiency, does this mean that they do not have hemisphericity dominancy?[40].

The special system that regulates motor activities among females exists behind the cerebral cortex. A number of factors contribute to raise the level of fine sensory motor skills among females. First, slow movement of females' muscle fibers compared to males. Also, the existence of barriers that prevents blood flow which reduces muscle spasm and stress[41]. Therefore, females are more skilful in the hand work that is associated with the visual significance which requires precision, patience and perseverance. Females outperform males in fine motor skills of which is sensory motor integration. This may be attributed to fluctuations in the Progesterone and Estrogen hormones among females. Low levels of this hormone improve scores on mathematics and special tests; while high levels of this hormone leads to improvement in language and fine motor skills[42].

The current study agrees with Lissek et al[27] who indicate that females activate cortex in motor performance. It also varies with Fulbright[20] and Webb[21], who indicates that there is a relationship between the left hemisphere and motor performance. The study, in addition, disagrees with Sheikh[8] and Albert[23] who point that there is no correlation between hemisphericity and motor performance.

3. Conclusions and Recommendations

The results suggest few recommendations, most important: to study the causes of differences between males and females with regard to sensory-motor integration, and the development of appropriate psychosocial programs for each gender. Depend on the results of sensory-motor integration tests to take decisions of moving students to a higher class or keep him in the current class. The study also recommends of further studies on hemisphericity dominancy with variables related to psychological aspects of different ages. It also recommends of collaboration between neuroscientists and educational researchers in designing training programs that serve the teaching process based on brain research results. It also recommends the following:

1. Since the study found a direct linear proportion correlation between each style of thinking and learning on one hand and sensory motor integration on the other, and because Herrmann seeks multiple stereotypes at individuals and focuses on the use of all mental processes in all parts of the brain because of their importance in learning and solving problems creatively, recommends that teachers and educational developers to develop learning patterns in the brain parts through diversification of learning activities that pertains every style.

2. Since the study found that the linear correlation between learning and thinking styles (Q-C, Q-D) and performance of sensory motor integration among female students which recorded significantly higher results compared to males results, it recommends of exploiting such learning styles characteristics during the learning process, and to consider harmony between homework and learning styles characteristics.

3. Since the results showed no significant difference at (0.05 = α) in the correlation between (Q-B, Q-A) learning styles and sensory-motor integration test among the study sample students due to gender variable, as well as no significant differences at (0.05 = α) in the correlation between (Q-D, Q-C, Q-B, Q-A) learning and thinking styles and sensory motor integration test due to different age group, the study recommends researching on learning characteristics of each style by curriculum developers, and to establish flexible curriculum that fits learning characteristics and thinking skills of each quadrant according to Herrmann of learning styles, to comply with all students with different learning patterns. It also recommends of training teachers to design instructional notes that correspond and meet with each learning style of educational material.

4. More researches to reveal the impact of concordance between learning styles and sensory-motor integration of other classes are recommended too.

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i Quadrant : Upper Right Brain
ii Quadrant : Lower Right Brain