Available online at www.elixirpublishers.com (Elixir International Journal)

Educational Technology

Elixir Edu. Tech. 87 (2015) 35764-35770

ISSN: 2229-712X

The Interrelation between Iranian EFL Learners' Reading Comprehension and Brain Quadrants

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ARTICLE INFO

Article history:
Received: 12 August 2015;
Received in revised form:
08 October 2015;
Accepted: 13 October 2015;

Keywords
Reading comprehension,
EFL learners,
Brain quadrants,
Herrmann's Whole Brain Model.

ABSTRACT

Over the past decades, studies of language skills have showed the importance of reading comprehension ability among EFL learners. This study aimed at determining the relationship of brain quadrants with reading comprehension skill among Iranian EFL students. The study was based on Herrmann's Whole Brain Model. 110 University students studying TEFL at Islamic Azad University of Mashhad were randomly selected for the purpose of this study. Herrmann's Whole Brain Dominance questionnaire and a standard TOEFL reading comprehension test were used in the study in order to measure students' brain quadrant preference and reading comprehension ability. The results of statistical analysis indicated that there was a positive relationship between brain quadrants and reading comprehension ability. The study concluded that students, who were D quadrant preference, performed significantly better (P < .05) than the other learners on reading comprehension test.

Introduction

Learning a foreign language depends on a number of biological, social, and educational factors, such as aptitude for languages, attitude, cognitive style, learning strategies, neurological factors, personality, previous experiences with language learning, proficiency in the native language, sense modality preference, sex, learning and thinking styles, etc.

The idea of learning style comes from general psychology. Learning style refers to the characteristic ways in which individuals are oriented to problem solving (Ellis, 2008).

Keefe (1979) defines learning style as the characteristic cognitive, affective and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact and respond to the learning environments. Learning styles, therefore, reflect the totality of psychological functioning (Willing, 1987). Learning styles can be distinguished from abilities (such as language aptitude) in that they constitute preferences that orient a learner to how they approach the learning task rather than capacities that determine how well they learn (Ellis, 2008).

William Edward "Ned" Herrmann (1922 - December 24) is known for his research in learning styles and Whole Brain Methods. He spent the last 20 years dedicating his life to applying brain dominance theory to teaching, learning, increasing self-understanding and enhancing creative thinking capabilities on both an individual and corporate level. Herrmann's contribution to the application of brain dominance brought him worldwide recognition. In 1992, he received the Distinguished Contribution to Human Resource Development Award from ASTD. In 1993, he was elected President of The American Creativity Association (Herrmann, 1996).

Herrmann classified learning styles based on functions controlled by each chamber of the brain (Lumsdain, 1999). Herrmann (1999) called this classification as a Whole Brain Model. Four divisions have been identified within the chamber of the brain, each chamber with a certain learning style as in the following:

A. The upper left quadrant (QA) represents external learning, which is logical, rational, realistic, analytical, critical, deducting and verbal. Learners falling within this category learn through traditional methods of the textbook and the teacher (Herrmann, 1999).

B. The lower left quadrant (QB) represents procedural learning, in which learning is characterized as sequential, structured, planned, regulated, and individualized (Herrmann, 1999)

C. The lower right quadrant (QC) describes the interactive learning in which interrelations and kinesthetic work are emphasized. Learners of this pattern are sensory, cooperative, emotional and explorative. The learning context is created by experience, feedback, listening, and shared thinking (Herrmann, 1999).

D. The upper right quadrant (QD) represents the internal learning, which focuses on comprehensive, creative, imaginative, and inductive ways of learning (Herrmann, 1999).

The learning context is characterized by insightfulness, idea construction and intuitive concept apprehension (Herrmann, 1999).

Herrmann (1995) also asserts that the whole brain model determines a person's preference for thinking in four different modes that are based on the task specialized functioning of the physical brain. According to Herrmann (1995), preference for the A quadrant(left cerebral mode) means that a person favors activities that involve logical, analytical and factual information combined with an ability to perceive, verbalize and express information precisely. Preference for the B quadrant (left mode) is similar to A quadrant thinking preference. Individuals with a B quadrant preference favor organized, sequential, planned and detailed information. They like to keep things as they are. A preference for the C quadrant (right limbic mode) indicates a preference for information that is interpersonal, and involves emotion and feeling. Preference for the D quadrant (right cerebral mode) is mainly described by creative, imaginative, conceptual and inductive ways of thinking.

Statement of Problem

Reading comprehension is what allows the reader to interact with the text in a meaningful way. Reading comprehension is the bridge from passive reading to active

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reading -- from letters and words to characters and contexts. It is the crucial link to effective reading -- a strong factor in our educational and professional lives. For many, reading comprehension also unlocks the door to a lifetime of reading recreation and enjoyment. In addition, this skill is mostly emphasized in educational settings. However, reading comprehension needs to be learned by new ways and techniques. There are still some tips and limitations on teaching reading. One way that can help teachers to improve learners' comprehension ability is through understanding specific brain quadrant which performs better at reading comprehension.

By understanding preferred brain quadrant, teachers can accommodate their teaching techniques of reading to that preferred thinking style.

The aim of the study

The purpose of the study is to determine the relationship of Herrmann's Whole Brain Model with reading comprehension.

Significance of study

There are some studies on Herrmann's Whole Brain Model. For example, Shelnutt (1996) conducted a study to identify learning styles in a group of engineering students. In addition, Abdullah, Balasingam, Krishnan, & Fong (2002) conducted a study to determine which thinking modes were most or least preferable among a group of students from the Curtin University of Technology Sarawak Campus of Malaysia, East Malaysia from University of North Carolina. Furthermore, Nawfal (2008) studied the psychometric characteristics of Herrmann's Brain Dominance instrument and explored the brain dominance mode among university college students.

However, very few research studies have embarked on investigating the relationship between brain quadrants and reading comprehension ability. This condition also exists for the relationship between the blood group and brain quadrants.

Moreover, knowledge obtained through the findings of this research will shed new light on new ways of teaching reading comprehension skill. When teachers know about the relationship between reading comprehension skill and kind of thinking style, they will apply many proper ways to strengthen reading comprehension skill in the language classroom.

The study is trying to answer the following question:

1. To what extent is students' ability of reading comprehension related to Herrmann's Whole Brain Model?

Literature

Problems of second language learning

The field of second language acquisition has historically blamed language learning failure on a number of factors. For instance, anxiety in the foreign language classroom (anxiety about making mistakes in grammar and pronunciation, about understanding the teacher, about remembering vocabulary) has been prominent as a purported cause of the failure (Reid, 2005; Brown, 2008). Among other causes cited in the literature has been lack of effort, lack of motivation, poor language learning habits, variety of learning style and mismatch between learning styles and teaching styles (Robin, 1977; Herrmann, 2002).

Some problems arise when a student struggles in school because a teacher's teaching style conflicts with the student's learning style (Heard, 1999). Due to the many learning style combinations found in our students and the miscommunication that occurs during information delivery, teachers have to re-teach a topic because information delivery conflicts with how students received and processed the information (Tileston, 2005).

Although every human being has a specific learning style, teachers often believe the way they learned in school is the best way to teach because of good results previously experienced, and feel that students should have the same positive outcome. However, research did show that the teaching and learning style of a teacher often did not match the learning style needs of students (Herrmann, 1995). This led to under-achievement in students. The physical learning environment (like lighting levels, seating, furniture arrangement, temperature, etc.) and emotional environment were essential factors in a child's day, which was upset by situations such as conversations cut short in between classes, an overcrowded classroom, unreasonable rules, or impossible deadlines. All of these caused a threatened feeling and significantly reduced a student's ability to learn a second language (Herrmann, 2002).

Herrmann's Whole Brain Model

William Edward "Ned" Herrmann (1922 - December 24) is known for his research in learning styles and Whole Brain Methods. He spent the last 20 years dedicating his life to applying brain dominance theory to teaching, learning, increasing self-understanding and enhancing creative thinking capabilities on both an individual and corporate level. Herrmann's contribution to the application of brain dominance brought him worldwide recognition. In 1992, he received the Distinguished Contribution to Human Resource Development Award from ASTD. In 1993, he was elected President of The American Creativity Association (Herrmann, 1996).

Herrmann's model consists of two theoretical components namely, functional specialization and dominance (Herrmann 1995). Herrmann's whole-brain model was the result of combining Paul D. Maclean's triune brain theory and Roger W. Sperry's left brain/right brain theory (Herrmann, 2002). When these two brain theories are combined, and the reality of brain dominance is considered, then, according to Herrmann (1995), we have the essential elements of an organizing principle upon which a working model of brain function can be based.

Herrmann's whole-brain model is metaphorically illustrated by using a circle to represent whole-brain thinking. The circle is then divided into four quadrants, which represent of our different thinking modes. Learners are classified according to their preferences for thinking in the four modes (Herrmann, 2000).

The four quadrants are suggested by Herrmann as following:

Quadrant A (left cerebral hemisphere). Learner that has a preference for quadrant A is characterized as being an analytical, logical, and critical thinker. This learner is also good at solving problems and collecting factual information. When making decisions these individuals rely on logic together with the ability to understand, verbalize and express things very accurately. Facts are regarded as important in supporting verbal statements (Herrmann, 1995).A quadrant A-only individual is a master of logic and reason. He/she processes information all the time even if it opposes the validity of an existing formula. A-only's output consists of principles, mathematical formula, and conclusion as to where to go next. His natural abilities make him the ideal problem-solver. When A-only carries out a task he thinks of the most efficient way, the way that will require the least amount of effort. These individuals tend to avoid emotion altogether. If confronted with emotional problems these individuals will see how they can fill a need without having to confront their emotions (Herrmann, 1995).

Quadrant B (left half of the limbic system). This quadrant favors sequential thinking and these individuals like things to be organized. They enjoy structure and detail and like things to have a plan (Herrmann, 1995).

Quadrant B individuals share certain similarities with quadrant A individuals. They both favor a linear approach to things and reject ambiguity. They both distrust emotions and intuition and both have the tendency to control their environment and themselves by imposing thought over reality. Both of them are efficient. They, however, differ in a number of important ways. An individual that has a preference for this quadrant lives in a neat, dependable world where decisions are based on long-established rules. The strength of the quadrant B individual is the ability to focus on one thing at a time. They are also very precise when it comes to detail. The B-only individual is stubborn and demanding on himself. As a result of this, others often view these individuals as domineering, small-minded, boring, insensitive and anti-social (Herrmann, 2002).

Quadrant C (right half of the limbic system). These individuals can be described as sensitive and receptive. Descriptions of this quadrant are: emotional, interpersonal, and sensory kinesthetic, and symbolic. These individual are sensitive to changes in mood, atmosphere, attitudes, and energy levels. This normally occurs in a very comforting and conciliatory way. Although a C-only individual is intensely aware of the world and especially the people around him/her, they are perceived through his/her own internal experience. These individuals are described as being kinesthetic. The primary modes of this quadrant are the emotional and the spiritual. Personal satisfaction is seen as the most important measure of success for anything. These individuals are spiritual, empathetic, nurturing, and musical (Herrmann, 1995).

Quadrant D (right cerebral hemisphere). These individuals are characterized as being visual, holistic, and innovative. D-only likes the excitement of new ideas, possibilities, variety, incongruities, and questions that sound obvious but in essence cut to the heart of the matter. These individuals tend to be true visionaries. D-only's, however, are unreliable when it comes to meeting deadlines or completing tasks. D-only's are not good at working with others because they are, firstly, nonverbal and, secondly, they are impersonal. These individuals need to accommodate the realities of the other quadrants by regarding them as useful contributions to their own process, rather than seeing them as hindrances or obstacles (Herrmann, 2002).The whole-brain model has been used in a number of fields and environments. These incorporate personal growth, counseling, group processes, teaching and learning, decision making and management.

The Theory behind Herrmann's Whole Brain Model

Herrmann (2002) considers dominance as natural and normal in organisms that result from experiences and conditions faced by the organisms on a daily basis. For example, the human body greatly involves paired structures, which in most cases are identical in one way or another. A good example of resemblance and identical structures are hands, feet, legs, eyes, etc. See figure 1.2 below, which in fact represents a schema that embodies the concept of dominance, wherein dominance starts as early as infancy growing over time by experiences, experiments, and daily use.

Herrmann (2002) supported this observation noting that it is reasonable as, for example, when we use our right hand or right arm to do a variety of activities they will become stronger. Your right arm or hand as a result will be strong enough to perform such action like carpentry, handwriting, drawing, and other activities. Herrmann also argued that there are other paired organs that couldn't be directly visible as they are internal to the human body such as lungs and kidneys. Such are physical examples of the existence of dominance. Paired organs of the human body, both internal and external, led Herrmann to construct his preconception of the dichotomies structure of brain.

For Herrmann, the human brain consists of two hemispheres and two limbic that are strongly linked with each other by linkages that allows the four parts to function systematically. Herrmann assimilated the coordination of hands, feet, and eyes with the double structures of brain noting one difference; that is their unique physical and chemical composition and functional specialization; i.e. to think in different ways and perform various mental tasks (Herrmann, 2002). The example cited by Herrmann (2002) is our dominant hand that is used more than the non-dominant hand, and the frequent use makes it stronger and empowered to perform various tasks and actions. The same applies to the brain. The preferred thinking in certain ways more often means frequent use of specific part of the brain; one hemisphere or one limbic half; thereby it develops and grows to become more efficient by practicing a variety of mental activities. The same as the underdeveloped and non-dominant hand help the skilled and dominant hand, developed structures of brain work cooperatively with more preferable and more dominance in the mental operations to produce better mental power with greater ability to accomplish day-to-day tasks and events. It is, therefore, natural that the human brain forms a cooperative unit of specialized structures to cope with more intricate situations given that the developed brain forms an integrated unit of many different preferences (Herrmann, 2002). As we see, Herrmann used the analogy of body parts and how they function to explain how the brain functions in relation to its component parts. From Herrmann's view, as already discussed-the brain consists of four areas of preferences (QA, QB, QC, and QD). Herrmann, as a result, developed his internationally accepted scale for the purpose of classifying individuals relying on their preferences of thinking (preferable thinking styles).

Reasons for choosing Herrmann's Whole Brain Model

The reason for choosing Whole Brain Model is its advantages for two groups:

Advantages for Instructor

By learning about our own preferences and understanding the diversity of thinking styles our students possess, we are able to insure that students understand what we are teaching even if they have very different styles from our own. We can do this by incorporating elements and activities that reach all learning styles. For instance, an English teacher who assigns a paper and tells students the paper should be "as long as it takes to effectively make your argument" will be well received by students with primary preferences in D quadrant. But a student with a B quadrant preference is likely to be immobilized by the lack of specific direction. The instructor could alleviate much of the B student's fear by simply giving a range of pages for the assignment and an outline of what makes an effective argument (Biech, 2009). An instructor who incorporates all learning styles into his teaching will find more receptive students experiencing less difficulty in his courses.

Advantages for Students

It's a diverse world, and probably the greatest diversity our students will ever encounter is the diversity of thinking styles because there are definitely different (Coates, 2006). By helping students recognize their preferred and less preferred styles, we are also assisting them with college. Not all instructors will embrace the idea of adapting their teaching to all styles, and certain elements of life and learning will always favor certain styles. Students will be better prepared to negotiate these courses if they can understand the thinking style in use and adapt their

studying and note-taking to their own more preferred styles. A student who learns to understand and appreciate all styles will more easily adapt to new challenges in college, at work and in his/her personal relationships (Fleming, 2001).

Studies on the relationship between brain and reading comprehension

Brain-imaging techniques such as Magnetic Resonance Imaging (MRI) have been shedding light recently on how our brain adapts optimally to the tasks of reading and spelling. Hempenstall (2006) conducted a study based on this method.

Hempenstall (2006) indicated that when good readers confronted text, it was seen that they heavily rely on separate areas in the left side of the brain. These areas were employed cooperatively to convert letters into sounds, fit the sounds together to make words, and to do so fluently. In the brain images, the three areas lighted up quite clearly while such students were reading.

In addition, in Hempenstall's idea, the left brain's parieto-temporal region became primed to decode (sound out) words, whether they be known or unknown words. Progressively, as the readers saw words in print, they started to build a neural model of that word. After they had correctly decoded a word a number of times, their neural model was an exact replica of the printed word. It specified the way the word was pronounced, the way it was spelled, and what it means. In an accurate neural model, all these features were bonded together (Hempenstall, 2006)

These features clarify and store these new internal representations in the occipito-temporal region. When that word became represented in the occipito-temporal region, its recognition subsequently became automatic and instant - in about one sixth of a second. This was faster than one could predict the upcoming word. When this process occurred, students began to display rapid, effortless word recognition rather than the slower sounding out strategy.

Hempenstall (2006) stated that it was tempting of course to suggest that children not be taught to sound out because that wasn't the way skilled readers were seen to respond to print. However,

Hempenstall (2006) concluded that you couldn't access the occipito-temporal region without first building up the parieto-temporal region. Normally, 4-14 accurate sounding-outs would create the firm links in the brain for building up the parieto-temporal region. For some children, it might take time – not all children have strong phonological skills (a talent for discerning small units of sound).

Hempenstall (2006) also revealed that those who struggled to read did not use the same brain regions for reading. Instead, they created an alternative neural pathway, reading mostly with regions on the right side of the brain - areas not well suited for reading. He stated that it was purely a compensatory strategy involving the visual centers of the right hemisphere - looking at words as if they were pictures. In his idea, little activity was observed in the phonological areas of the left hemisphere where capable readers' activity is dominant.

At the end, Hempenstall (2006) stated that the brains of people who couldn't sound out words look different - there was less blood flow to the language centers of the brain.

Methodology

Participants

Participants in this study were 110 university students, studying at the Islamic Azad University of Mashhad. They were TEFL major who were both males and females. The 110 TEFL major students were randomly selected from five different classes. There were 22 TEFL students in each class.

Instruments

Herrmann Brain Dominance Instrument

Herrmann Brain Dominance Instrument (HBDI) was utilized in this study in order to assess participants' brain quadrants preference. HBDI was taken from Herrmann International Group. It consisted of 120 questions. These questions were related to four brain quadrants (thinking styles). Herrmann Brain Dominance Instrument (HBDI) was translated by the researcher into Persian. The cultural aspects of the questionnaire were also taken into consideration in the process of translation to meet the validation requirements. Herrmann Brain Dominance Instrument (HBDI) was developed by William Edward Ned Herrmann.

Reading Comprehension Test

In order to measure students reading comprehension ability, a standard reading comprehension test was administered by the researcher. The test consisted of four passages with 5 questions in each passage with appropriate level of difficulty. It was a standard reading test which was taken from TOEFL textbooks.

Procedure

In the early autumn of 1393 the researcher administered the thesis at the Islamic Azad University of Mashhad.

The researcher went to the faculty of English language and randomly selected five classes in order to apply the test. All participants were majoring in TEFL. There were 22 TEFL students in each class.

At the beginning, the researcher held an introduction session. The purpose was to introduce the Herrmann questionnaire to the participants. After that, one hundred and ten TEFL students were asked to fill out Herrmann Brain Dominance Instrument. In addition, a standard reading comprehension test, which was attached to HBDI, was answered by TEFL students. Thesis examination was done by the researcher in the Faculty of English language in three weeks.

After collecting the required data, Herrmann questionnaire was scored based on frequency distribution. As each item in HBDI was related to one brain quadrant, frequency was calculated in order to specify quadrant preference of 110 questionnaires. After scoring of 110 questionnaires, reading comprehension test was scored from a total of 20 points.

Then, the researcher utilized ANOVA test to determine the relationship between reading comprehension and brain quadrants. To assess the relationship between a quantitative variable (reading skill) within qualitative groups (brain quadrants), analysis of variance (ANOVA) was used by the researcher.

Results

Analysis of the data

After the required data were collected, Herrmann questionnaire was scored based on frequency distribution in order to specify quadrant preference of questionnaires. After scoring of 110 questionnaires, reading comprehension test was scored from a total of 20 points. Then, the researcher utilized analysis of variance (ANOVA) test to assess the relationship between a quantitative variable (reading skill) within qualitative groups (brain quadrants).

First research question and hypothesis

To what extent is students' ability of reading comprehension related to Herrmann's Whole Brain Model?

Hypothesis: Students' ability of reading comprehension is positively related to Herrmann's Whole Brain Model.

Table 1. Reading Comprehension Scores and Quadrant Preferences

Quadrant A Scores

17	16	18	14	12	15	12	17	12	14	19	15	16	14	17	17	15	14	15	15	14	14	13	18	17

The above table shows reading comprehension scores of students who are A quadrant preference. Reading comprehension test scores are reported on a 0-20 score scale.

Quadrant B Scores

17	11	12	10	15	15	15	16	15	17	17	14	12	19	15	14	16	16	14	18	14	11	11	10	13

The above table shows reading comprehension scores of students who are B quadrant preference. Reading comprehension test scores are reported on a 0-20 score scale.

Quadrant C Scores

18	18	15	19	19	14	16	15	14	13	17	17	11	18	12	19	17	17	15	16	15	17	17	17	16

The above table shows reading comprehension scores of students who are C quadrant preference. Reading comprehension test scores are reported on a 0-20 score scale.

Quadrant D Scores

17	19	15	16	16	16	18	16	16	13	14	16	16	16	15	18	19	19	17	17	15	15	14	15	17

The above table shows reading comprehension scores of students who are D quadrant preference. Reading comprehension test scores are reported on a 0-20 score scale.

Table 2 .Total Distribution of Brain Quadrants and Reading Skill Mean Scores

Brain Quadrants	samples	Mean	S.D	S.E.M	Confidence Intervals		Min	Max
					Low	High		
Quadrant A	25	15.2	1.95	0.39	14.3	16	12	19
Quadrant B	25	14.2	2.5	0.5	13.2	15.3	10	19
Quadrant C	25	16.08	2.11	0.42	15.2	16.9	11	19
Quadrant D	25	16.2	1.58	0.31	15.5	16.8	13	19
Total	100	15.4	2.18	0.21	15	15.8	10	19

The above table represents a general description of the top quadrants' abundance. As you can see in the above mentioned table, A quadrant's mean score is 15.2, B quadrant's mean score equals 14.2, C quadrant's mean score equals 16.08 and D quadrant's mean score is 16.2. It should be mentioned that the scores represent 0 to 20.

Table 4.3. Analysis of Variance Table

Source	Sum of Square	Degree of freedom	Mean Square	F-Statistics	P-Value
Between Groups	59.7	3	19.9	4.6	0.004
Within Groups	410	96	4.2		
Total	470	99			

The above table represents the findings pertaining to the analysis of variance (ANOVA).

Table 4. Duncan Test Table

Brain Quadrants	Subsets	
	1	2
Quadrant A	14.28	
Quadrant B	15.2	15.2
Quadrant C		16.06
Quadrant D		16.2
Significant level	0.119	0.110

For answering the question, the researcher utilized descriptive statistics and (ANOVA) test to assess the relationship between a quantitative variable (reading skill) within qualitative groups (brain quadrants).

First, 100 answered questionnaires and reading comprehension tests were randomly selected (out of 110) for each brain quadrant. For the purpose of study, the researcher selected 25 samples for each brain quadrant.

Students with quadrant A: 25 samples
Students with quadrant B: 25 samples
Students with quadrant C: 25 samples
Students with quadrant D: 25 samples
Total : 100 samples

Based on the analysis, the following reading comprehension scores and quadrant preferences were obtained.

Regarding the signification level of the F test (0.004), the difference in the mean scores within the four groups seems to be significant and is feasible to generalize to the statistical population (0.05>P-Value). In other words, the results of the statistical analysis indicated that students who were D quadrant preference, performed significantly better ($p<.05$) than other learners on reading comprehension test. According to the Herrmann's Whole Brain Model, quadrant D is located in the right side of the brain (Herrmann, 2002).

Therefore, Students' ability of reading comprehension is positively related to brain quadrants.

After the existences of a significance difference among the reading skill mean scores in the brain quadrants has been determined, the question is how this difference can be attributed in relation to four quadrants. . In cases such as this one, some tests like Duncan test are used.

The following table represents the results for this test.

Considering the signification level of A and B quadrants together, as you can see in the above table, there's no difference in average (0.05< P-Value) and they fall into the same group. Also, there's no difference in average within the B, C and D quadrants and they fall into the same group (0.05< P-Value).

Discussion & Conclusion

In this study the aim was to see whether there is any relationship between the Iranian learners' reading comprehension and brain quadrants based on the Herrmann's Whole Brain Model.

The results showed that the relationship existed between Iranian EFL learner's reading ability and their brain quadrants based on Herrmann's Whole Brain Model. In other words, the results of the statistical analysis indicated that students who were D quadrant preference, performed significantly better ($p<.05$) than other learners on reading comprehension test. According to the Herrmann's Whole Brain Model, quadrant D is located in the right side of the brain (Herrmann, 2002).

The results of the previous study (Hempenstall, 2006) revealed that there was a relationship between reading comprehension and left side of the brain. Hempenstall (2006) concluded that when good readers confronted text, it was seen that they heavily rely on separate areas in the left side of the brain. These areas were employed cooperatively to convert letters into sounds, fit the sounds together to make words. In his view, with this capacity, the left brain's parietal-temporal region became primed to decode (sound out) words, whether they are known or unknown words. Therefore, findings of the current study are not in line with findings of the Hempenstall study. In this study, the students, who were D quadrant preference, performed significantly better than other learners with other quadrants (A, B, C). Quadrant D is in the right brain.

In addition, what can be concluded from the findings of the current study is that students, who were D quadrant preference, performed significantly better than other learners with other quadrants (A, B, C).

Furthermore, different assumptions can be inferred from this study. First, quadrant D is the center of creativity in the brain (Herrmann, 2002). Here, we can understand the value of creativity in educational settings. What is worth mentioning is that students with high creativity are more successful than other students. Unfortunately, according to the current study, number of creative and D quadrant preferred students are decreasing in our country. Probably, it is because of methods of teaching and learning in Iranian schools. Unfortunately, most of Iranian schools emphasize on left brain teaching.

Nowadays, memorization and rote learning are common among Iranian students in educational settings. In contrast, most of developed and modern countries have emphasized the role of right brain and creativity in their educational curriculum (Herrmann, 1995).

When the role of right brain and creativity are taken into consideration, there will be more educated students (Herrmann, 2002). Moreover, some useful activities can be inferred from quadrant D to enhance reading comprehension ability.

Implications of the study

Implications are two-fold. First, teaching and assessment methods not amenable to any specific brain quadrant are components of a general teaching and assessment strategy (Herrmann, 2002)

Second, teaching and assessment methods preferred by specific brain quadrant hold implications for learning activities, skills development and learning outcomes (Herrmann, 2002). Educators can use the results to develop a 'whole-brain' approach to teaching by designing courses that draw on general and dominance-specific methods.

For example, combining lectures with detailed in-class example and problem-solving sessions followed by discussion or debate to assess understanding facilitates development of analytical, organizational and creative skills (brain quadrants). Classrooms represent a spectrum of learning preferences and educators can employ whole-brain teaching to make sure that learning points are taught multiplicatively. The results add fresh insight to the broader debate on learning styles, showing how selecting methods to target specific quadrants of the brain can trigger students to engage deeply.

In addition, the study implies that curriculum designers and educators must be careful not to make false assumptions about learners in the classroom. Indeed the project reveals that there is a distribution of learning preferences in all quadrants and that all modes are equally represented. The research project endorses documented research findings (Herrmann, 1995) that just as there are a distribution of thinking preferences across the spectrum of all four quadrants in the classroom, there is also a distribution of learning avoidance across the four quadrants. Learning avoidance may even be more significant to educators than learning preferences because a "turned off learner is a waste of educational time and effort" (Herrmann, 1996, p.152). Therefore, the greater the alignment between the thinking preference of the educator and the thinking preference of the learner, the more competencies will be acquired by the learner. On the other hand the greater the misalignment the fewer competencies will be acquired (Vangundy, 2008).

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