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Differences in brain dominance patterns among second-year secondary school students in light of gender and academic branch variables

الفروق في أنماط السيادة الدّماغية لدى تلاميذ السنة الثانية ثانوي في ضوء متغيري الجنس والشعبة الدّراسية

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Abstract:

This field study aimed to identify the predominant brain dominance patterns among a sample of second-year secondary school students, and examine the differences in brain dominance patterns among students according to the gender variable, as well as examine the differences in the choice of academic branch among students according to their brain dominance patterns. To achieve this, a descriptive method was adopted. The study sample consisted of 395 students from two secondary schools in the state of Médéa. The data collection tool used was the "Herrmann" brain dominance scale in its Arabic version by the researchers Al-Turaihi and Kazem (2013), after application to the Algerian environment and verification of its psychometric properties by the researcher. The results showed that: the predominant brain dominance pattern among the study sample was pattern (B), followed by pattern (C), then pattern (D), and finally pattern (A); Statistically significant differences were found between males and females in brain dominance patterns: pattern (A) in favor of males, while pattern (C) in favor of females; Differences were also found in the choice of academic branch according to variations in brain dominance patterns among the students.

Keywords:

The brain dominance patterns; Herrmann's model; choice of academic branch.

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1. INTRODUCTION:

God distinguished humans from all other creatures with the gift of intellect and the ability to think. It is well known that the organ associated with thinking is the brain, which governs many behaviors. Brain researches are significant topics for medical and neuroscience researchers, psychologists, and Specialists in thinking and learning. The latest findings in this field are represented by the Theory of the Two Hemispheres of the Brain, which indicates that each side of the brain (right and left) has its way of handling situations, and one side may dominate over the other in an individual; It is dominant in his thinking, learning method, daily practices, and various preferences and tendencies; According to Özyel (2016), the terms hemispheric dominance, brain dominance, or cerebral dominance mean that learners tend to use one side of the brain more than the other. Many studies have indicated that researchers' interest in the subject of brain dominance is due to several consideration; Neurologists utilize it to investigate brain functions, while psychologists and educators use it to understand the processes of perception, information processing, and learning patterns; to enhance education. According to the study by Bawaneh & al. (2011), and based on the results reached, the study recommended identifying students' thinking patterns and supporting them to learn according to the characteristics of each pattern, in order to develop the skills included under each thinking pattern, and taking these individual differences into account when designing curricula. This highlights the importance of identifying each learner's brain dominance pattern, enabling us to determine the learning styles they are enthusiastic about and excel in. It also helps align the learner's preferences with the requirements of the field of study to which he will be directed, thereby achieving meaningful learning according to the proponents of the cognitive approach.

Several concepts have emerged among scientists who studied the divisions of the brain, which we encountered during our review of the theoretical literature on this subject. These include brain dominance, cerebral dominance, brain sovereignty, hemispheric and lateralization. In this study, we have chosen to use the concept of "brain dominance", especially since the measure used in our study is titled the "Brain Dominance Scale". We will rely on Herrmann's quadripartite division of the brain. According to Al-Turaihi & Kazem (2013, p. 110), Herrmann conducted studies since 1974 and proposed a symbolic quadripartite division of the brain, where each quadrant represents a type of brain dominance pattern as follows: the upper left quadrant (A), the lower left quadrant (B), the lower right quadrant (C), and the upper right quadrant (D). Herrmann (2002) also mentioned that academic subjects based on logic and sequence, such as sciences, mathematics, and language, are associated with the left side of the brain. In contrast, academic subjects requiring holistic thinking, such as humanities and arts, are linked to the right side of the brain. According to this, learners

are divided into four categories corresponding to the quadripartite division of brain dominance patterns.

From this perspective, questions arose that paved the way for our study regarding whether one brain pattern is dominant among our students, where there is still conflict in the results according to the studies and research we have reviewed in this field; some studies have found a dominance of the brain's left hemisphere, while others have concluded a dominance of the right hemisphere.

Regarding the differences in brain dominance patterns by gender, most of the studies we reviewed did not agree on a single result, showing variations among researchers' findings. Some studies have shown that there are differences between males and females in brain size and how information is processed. For instance, Razumnikova & Volf (2012) concluded in their study that there were no differences found in brain dominance between genders in general., although there were differences in specific situations to which they were subjected. While Nemer's study (2015) found that no differences in the brain's dominant learning patterns attributable to the gender variable. Taifour et al. (2021) study also found that no effect of gender on brain dominance patterns. and the study Nawafleh et al. (2024) also concluded that there were differences in all brain dominance patterns attributed to the gender variable.

We can say that even if the results of studies on the differences in brain dominance patterns by gender vary, the association of each pattern with distinctive thinking and learning styles is agreed upon by many researchers, especially those who rely on Herrmann's theory to explain the learning process. Among the most notable findings in this field is that learners with pattern (A) learn through analysis, facts, and data, while those with pattern (B) learn in an organized and precise manner. Learners with pattern (C) prefer to learn through their sensory intuition, and those with pattern (D) favor learning through imagination, exploration, and creative thinking (Al-Turaihi & Kazem, 2013, p.110). Understanding the importance of differences in learners' brain dominance patterns is beneficial for building teaching and learning processes. It plays a crucial role in the proper guidance of learners, whether at the secondary or university level if considered.

After reviewing the theoretical literature and previous studies, and given the scarcity of research on this topic, especially in the Algerian context (to the best of our knowledge), and the differences from our study in terms of sample, objectives, theoretical approach adopted, or choice of study tools; we decided to examine the brain dominance patterns among learners in light of the variables of gender and the choice of academic branch. We will attempt to answer the principal question:

- What are the predominant brain dominance patterns in order among second-year secondary school students (study sample), and are there differences in these patterns according to the variables of gender and choice of academic branch?

This principal question leads to the following sub-questions:

- What is the predominant brain dominance pattern among second-year secondary school students (study sample)?
- Are there differences in brain dominance patterns attributed to the gender variable among second-year secondary school students?
- Are there differences in the choice of academic branch according to the variations in brain dominance patterns among second-year secondary school students?

1.1- Hypotheses:

- **General Hypothesis**: After reviewing the theoretical background and previous studies related to the subject, we hypothesize that: There are differences in brain dominance patterns among the study sample according to gender, and differences in the choice of academic branch by students according to their brain dominance patterns
- **Sub-Hypotheses**:
  - Since the aim of the first question is exploratory, we did not formulate a specific hypothesis for it.
  - There are differences in brain dominance patterns attributed to the gender variable among second-year secondary school students.
  - There are differences in the choice of academic branch according to the variations in brain dominance patterns among second-year secondary school students.

1.2- Study objectives:

- To identify the predominant brain dominance pattern among the students in the study sample.

- To examine the differences in brain dominance patterns among the students (study sample) according to the gender variable.

- To study the differences in the choice of academic branches according to the variations in brain dominance patterns among the students in the sample.

1.3- Importance of the Study: The importance of this study can be summarized as follows:

- It is one of the attempts that focuses on the applications of brain research in the psychological and educational fields, particularly brain dominance.

- It highlights the importance of identifying brain dominance patterns and their role in determining learners' preferences and inclinations.

- It emphasizes the significance of creating a comfortable environment to achieve academic adaptation and psychological comfort for learners by considering their preferences and abilities and aligning them with their brain dominance patterns to enable them to excel in their chosen field.

- This study aligns with recent reforms in our educational system within the framework of competency-based education, which calls for attention to learners' abilities and the search for precise criteria to ensure proper guidance.

1.4- Definition of Concepts:

1.4.1- Brain Dominance Patterns: Brain dominance patterns refer to an individual's tendency to rely on one of the four brain patterns, where patterns (A) and (B) belong to the left hemisphere of the brain, and patterns (C) and (D) belong to the right hemisphere. A specific pattern tends to dominate over others when an individual engages in thinking activities such as information processing and other cognitive tasks. This is measured through the total scores an individual achieves for each brain quadrant on the Brain Dominance Scale used in this study, which is the Arabic version of Herrmann's scale. The scale comprises four sections, resulting in four scores: the subscore for the pattern (A), the subscore for the pattern (B), the subscore for the pattern (C), and the subscore for the pattern (D). The highest score an individual receives on one of the four branches of the scale determines which quadrant (pattern) of the brain is dominant.

1.4.2- Herrmann's Model: Herrmann's model is a quadripartite division, where the brain is symbolically divided into four parts called brain dominance patterns. These patterns determine an individual's thinking style and preferred methods for learning and problem-solving, as follows:

• **Upper Left Quadrant (pattern A):** This area is associated with thinking activities that require information based on accuracy, facts, logic, and analysis.

• **Lower Left Quadrant (pattern B):** This area is linked to sequential, organized thinking activities, and detailed structured information.

• **Lower Right Quadrant (pattern C):** This area is associated to thinking activities based on psychological aspects, emotions, feelings, and social relationships.

• **Upper Right Quadrant (pattern D):** This area pertains to thinking activities that rely on holistic concepts and a comprehensive view of the subject or element.

The dominant pattern of an individual is known by the highest score he obtains in one of the four branches of the scale, each of which represents one of the four patterns mentioned.

1.4.3- Choice of academic branch: academic branches are divisions of general specializations in secondary education that become more specific in university education. The selection of academic branch refers to the preference from Multiple; It is what the student chooses from among the academic branches that prepare for the specializations, which determine the trajectory of their educational and professional life. Students in their first year of secondary school choose between two divisions: the common core of Science and Technology and the common core of Literature and Philosophy. In the second year of secondary school, the common core of Science and Technology is divided into branches: Experimental Sciences, Mathematics, and Technical Mathematics (Civil Engineering, Electrical Engineering, Mechanical Engineering, Process Engineering); The common core of literature and philosophy is divided into branches :Literature and philosophy, and foreign languages.

2. Method and Tools

2.1- Research Method:

Given the nature of the topic and the study variables, a descriptive approach was adopted.

2.2- Sample:

The sample was selected randomly; Two (2) secondary schools were selected randomly from among the (54) secondary schools in the state of Medea, and the sample included all second-year students from these two schools. Because our study deals with choosing academic branch, we excluded the responses from students who did not get their preferred branches but were assigned based on their rates. Invalidated responses were also excluded, resulting in a final sample size 395. The following Table 1 shows the distribution of the study sample:

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Table 1: Distribution of the sample by gender and academic division

academic branches	Gender		Total
	Male	Female	
Literature and Philosophy	37	62	99
Experimental Sciences	49	82	131
Foreign Languages	14	50	64
Mathematics	04	03	07
Management and Economics	20	09	29
Technical Sciences (Electrical Engineering)	16	07	23
Technical Sciences (Civil Engineering)	19	07	26
Technical Sciences (Mechanical Engineering)	08	00	08
Technical Sciences (Process Engineering)	04	04	08
Total	171	224	395

2.3- Spatial and temporal scope of the study: This study was conducted in two high schools in the state of Medea, namely "Al-Ikhwa Mas'oudi" and "Boussila Maamar", during the second trimester of the academic year (2019/2020).

2.4- Study Tool: The study utilized the Brain Dominance Scale, adapted into Arabic from the original scale developed by Herrmann. The Arabic version was created Based on Hermann's original scale by researchers "Al-Turaihi and Kazem" from the University of Babylon, Iraq. Their adaptation, published in their (2013) book, involved rephrasing the items to fit the Arabic context while retaining the name "Herrmann Scale"; They conducted all necessary scientific procedures for scale construction, including verifying its psychometric properties before applying it in their researchs and others; It was also applied by the researcher in a previous study Bendjeddah & Mahieddine (2022) in the Algerian environment. The scale comprises 56 items, divided into four patterns: Pattern A, Pattern B, Pattern C, and Pattern D, with each pattern containing 14 items (see detailed procedural definitions: 1.4.1 and 1.4.2). The scale is designed to identify which part (pattern) of the brain predominates in a student's thinking and learning and to determine their preferences.

Table 2: dimensions of the scale and the arrangement of its items

dimensions	items
Upper Left Quadrant (A)	3 8 11 15 18 23 27 30 35 39 43 46 51 55
Lower Left Quadrant (B)	1 4 9 13 16 19 22 25 33 38 41 48 53 56
Lower Right Quadrant (C)	2 6 10 14 17 21 26 29 32 36 40 44 47 50
Upper Right Quadrant (D)	5 7 12 20 24 28 31 34 37 42 45 49 52 54

2.4.1- Psychometric Properties of the scale:

To verify the psychometric properties of the study tool and ensure the clarity of the scale's items in terms of language and meaning for students, a preliminary study was conducted with a sample of 171 students from the second year of high school, who were not part of the primary study sample. The findings were as follows:

-Validity: The validity of the Brain Dominance Scale in the current study was verified using two methods:

Content Validity: The scale was reviewed by a panel of ten (10) expert judges specializing in psychology, measurement, and educational sciences to verify the apparent and content validity. The agreement rate among experts was 82%. Based on their feedback, some adjustments were made: the response alternatives on the scale's items were changed from two options (Yes or No) to five (Always, Often, Sometimes, Rarely, Never) while keeping the total number of items at 56.

Internal Consistency Validity: This was done by calculating Pearson correlation coefficients between the total score of the scale and the total scores of the four sub-scales it comprises. This is shown in Table 03.

Table 3: Correlation coefficients between the total score of the scale and the total scores of the sub-scales

dimensions	Correlation coefficients	P-value
Upper Left Quadrant (A)	0.752	0.000
Lower Left Quadrant (B)	0.790	0.000
Lower Right Quadrant (C)	0.753	0.000
Upper Right Quadrant (D)	0.725	0.000

From the table (3), we observe that the correlation values between the four subscales of the Brain Dominance Scale and the total score are all high and statistically significant at a level less than 0.01. The correlation coefficients are as follows: For subscale (A): 0.75, subscale (B): 0.79, subscale (C): 0.75, and for subscale (D): 0.72.

These results indicate that the sub-scales are consistent with the total score of the scale.To confirm this, we calculated the correlation coefficients between each sub-scale and its associated items. The correlation coefficients were: For sub-scale (A), the correlations with its items ranged between 0.36 and 0.72. For sub-scale (B), the correlations with its items ranged between 0.38 and 0.67. For sub-scale (C), the correlations with its items ranged between 0.42 and 0.69. For sub-scale (D), the correlations with its items ranged between 0.32 and 0.71. All results were statistically significant at a level of 0.01. Thus, the scale is considered to have an acceptable level of validity.

-Reliability: To verify the reliability of the scores on the Brain Dominance Scale, we used two methods: the split-half method (Guttman) and Cronbach's alpha (α) for the four sub-scales scores. The total score of the scale cannot be dealt with, as each of the four sub-scales of the scale represents a specific pattern and a quarter of the brain, and thus each Sub-scales is considered a part of the scale independent of the other Sub-scales. The results are shown in Table 04.

Table 4: Reliability Coefficients - Guttman and Cronbach's Alpha (α) - for the Sub-scales

dimensions	items	Guttman coefficient	Cronbach's alpha
Upper Left Quadrant (A)	14	0.678	0.698
Lower Left Quadrant (B)	14	0.734	0.712
Lower Right Quadrant(C)	14	0.692	0.682
Upper Right Quadrant(D)	14	0.747	0.679

It is evident from Table (4) that the values of the reliability coefficients (Guttman, and Cronbach's Alpha) for the scores of the four subscales were generally close. We observe that the values of the "Guttman" coefficient for the scale branches ranged between (0.67 and 0.74), while the values of the "Cronbach's Alpha" coefficient for the branches ranged between (0.67 and 0.71), which are values within the acceptable range. This indicates the stability of the scale scores, allowing us to rely on its results for the current study purposes.

2.4.2- Scale Weights and Correction Method:

Weights were assigned to the scale alternatives as follows:

-Always: 4 points/ -Often: 3 points/ -Sometimes: 2 points/-Rarely: 1 point/-Never: 0.

Given that the scale contains four branches, we have four sub-scores. The total raw score for each branch is divided by 4 to maintain the correction key instructions of the original reference. Therefore, preference levels can be divided according to the total scores in each branch:

- From 0 to 4: Represents the lowest category, indicating no preference for the brain dominance pattern.
- From 5 to 9: Represents the medium category, indicating a secondary preference for the pattern.
- From 10 to 14: Represents the highest category, indicating a primary preference for the pattern (strong dominance).

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Thus, the dominance of a particular brain dominance pattern of an individual can be determined by the highest score obtained in that pattern compared to other patterns. For example, let's assume that the raw scores of an individual on the four subscales are as follows: score on branch (pattern) A: 52, branch B: 36, C: 24, D: 12. We divide each of these scores by 4, resulting in the following scores: A: 13, B: 9, C:6, D: 3. Comparing these scores, we notice that the highest score is for branch A, indicating that the dominant pattern for this individual is the pattern (A), while the other patterns are secondary for him, However, it cannot be entirely ruled out that he might also rely on a particular pattern among them.

2.5- Statistical Methods: The statistical methods used in this study included frequencies and percentages, arithmetic mean, standard deviation, Pearson correlation coefficient, reliability coefficients "Cronbach's Alpha" and "Guttman," Chi-square test for goodness of fit and independence, and the "T" test for significance of differences between means. This was done using the Statistical Package for the Social Sciences (SPSS v25).

3. RESULTS AND DISCUSSION

During the statistical processing of the data, we found that some individuals in the sample exhibited mixed patterns, this means that each of these individuals has two or three distinctive patterns of brain dominance, without a single principal pattern, as their scores were equal across two or three patterns. The number of individuals with mixed patterns was (40), as shown in Table (05):

Table 5: Distribution of Individuals with Mixed Patterns According to Brain Dominance Patterns and Academic branches

Academic branches	Shared Brain Dominance Patterns									Total
	AB	AC	AD	BC	BD	CD	ABC	ABD	BCD	
Litterature and Languages	2	0	1	4	6	1	0	1	0	15
Experimental Sciences	3	2	0	2	2	3	2	0	1	15
Mathematics	0	0	0	0	0	0	0	0	0	00
Management and Economics	1	0	0	0	1	0	1	0	0	03
Technical Sciences	2	0	0	2	2	0	0	0	1	07
Total	8	2	1	8	11	4	3	1	2	40

These 40 individuals with common patterns,were excluded from the total sample size of 395. Therefore, the statistical analyses will be based on a sample of 355 students.

3.1 Results and discussion of the first question: the first question of the study is: What is the dominant brain dominance pattern among second-year secondary school students (the study sample)? To answer this question, the frequencies of the sample individuals according to each dominant pattern were counted, as shown in Table 06.

Table 6: Distribution of patterns among the sample individuals

	Pattern A	Pattern B	Pattern C	Pattern D	Total
Number of individuals	38	127	122	68	355
Percentage	10.7%	35.77%	34.36%	19.15%	100%

From Table (6), it is observed that the predominant pattern among the sample individuals is Pattern (B). To verify the significance of this result, we applied the Chi-square goodness-of-fit test, as shown in Table 07.

Table 7: The Chi-square value for goodness-of-fit to test the differences in Distribution of brain dominance patterns among the sample individuals

Chi-square Value	Degrees of Freedom	P-value
63.506	03	0.000

From Table (7), we observe that the Chi-square value = 63.506 is statistically significant ($p < 0.001$), indicating that the differences observed are real and not due to chance. This means that the patterns frequencies are not equally distributed. It is noted that Pattern B is predominant among most of the sample individuals, followed by Pattern (C), then Pattern (D), and finally Pattern (A).

The results of our study indicate that the predominant brain dominance pattern among the students in the study sample is Pattern (B), which belongs to the left hemisphere of the brain. This aligns with many studies that Some of them indicate that the left hemisphere is dominant in approximately 85-90% of individuals, while the right hemisphere is dominant in 10-15% of others (Al-Mohammedi, 2017, p.136). This is also consistent with the findings of the studies by Mezyan & Zakai (2003) in Algeria, Nofal (2006), despite the differences in the characteristics of their studies samples compared to ours. These studies concluded that the left hemisphere is predominant. On the other hand, our study results contradict the findings of the study by Nemer (2015) conducted on high school students, which found that the right hemisphere is dominant.

The predominance of Pattern (B), associated with the lower left part of the brain responsible for control, organization, and routine, may be due to the teaching methods used by many teachers from the early stages of education through the academic level of our study sample, Classical instructional methods prevail, limiting opportunities for learners to exhibit creativity, talent, and emotional intelligence, which are characteristics of the right hemisphere. Therefore, it is essential to involve learners in the learning process and engage their senses through various modern active learning strategies, such as brainstorming, problem-solving, cooperative learning, and other strategies in line with the competency-based approach, which activates both sides of the brain; what is known as whole brain activation, according to Herrmann. The presence of a dominant pattern in an individual's thinking and learning does not mean that he is independent of other patterns that represent the other quadrants of his brain; rather, these patterns are considered secondary to him, and he can use them in other situations with the same importance as he uses his dominant pattern, and his dependence on a specific pattern cannot be completely denied.

3.2 Results and discussion of the second hypothesis: The text of the second hypothesis was: There are differences in brain dominance patterns attributed to the gender variable among second-year secondary school students. To verify this hypothesis, the mean and standard deviation were used as shown in Table 08.

Table 8: the means and standard deviations of genders according to brain dominance patterns

Pattern	Gender	Number	Mean	S.D	S.E.M
A	Female	202	7.74	2.340	0.136
	Male	153	8.36	2.795	0.241
B	Female	202	9.53	2.567	0.149
	Male	153	9.16	2.946	0.255
C	Female	202	9.48	2.862	0.167
	Male	153	8.43	2.931	0.253
D	Female	202	8.52	2.520	0.147
	Male	153	8.44	2.735	0.236

From Table (8), we observe that the highest mean scores for males (9.16) and females (9.53) are found in Pattern B, indicating the predominance of Pattern B among the study sample and confirming the results of the statistical processing for the first question; obtaining a consistent result through different statistical analyses provides greater reliability for the findings. We also observe from Table (8) that the mean score for males in Pattern (A) is higher than that for females in the same pattern. However, the mean scores for males are lower than those for females in the other three patterns

(B,C,D).To determine whether these differences between the gender means are significant or due to chance, we used the independent samples t-test, as shown in Table 09.

Table 9: Represents the t-test values for the significance of differences between genders for each pattern.

Pattern	t-Value	df	P-value	Difference Between Means	S.E of Difference	95% Confidence Interval for the Difference	
						Lower	Upper
A	-2.221	353	0.002	-0.616	0.277	-1.162	-0.069
B	1.313	353	0.190	0.368	0.280	-0.183	0.919
C	3.515	353	0.000	1.056	0.300	0.466	1.646
D	0.278	353	0.781	0.750	0.270	-0.455	0.605

From Table (9), we observe that for Pattern A, the t-test value is statistically significant ($t = -2.221$, $p = 0.002$). Thus, the observed difference between the mean scores of males and females in Pattern (A) is real and not due to chance, indicating that the mean score for males is higher than that for females in Pattern (A). For Pattern (B), the t-test value is not statistically significant ($t = 1.313$, $p = 0.190$). Therefore, the observed difference between the mean scores of males and females in Pattern (B) is not real and can be attributed to chance. For Pattern (C), the t-test value is statistically significant ($t = 3.515$, $p < 0.001$). Hence, the observed difference between the mean scores of males and females in Pattern (C) is real and not due to chance, with males having a lower mean score compared to females. For Pattern (D), the t-test value is not statistically significant ($t = 0.278$, $p = 0.781$), indicating that the observed difference between the mean scores of males and females in Pattern (D) is not real and can be attributed to chance.

Consequently, the second hypothesis has been verified, which is the existence of differences in brain dominance patterns attributed to the gender variable among second-year secondary school students.

The differences found in our study in brain dominance patterns attributed to gender are consistent with the study by Nawafleh et al. (2024); and so with the study by Razumnikova & Volf (2012) in some details such as the special situations to which both genders were subjected. However, our study results differ from those of Nemer (2015) despite their sample being at the same educational level as ours; And also the study by Taifour et al. (2021).

Our study found differences between genders in Pattern (A), with the difference favoring males, as their mean scores in this pattern are higher than those of females. This may be explained by the preference of males for scientific and mathematical fields, which involve logic, control, numbers, and calculations characteristic of Pattern

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(A). Females, on the other hand, often lean towards literary fields involving discussion of ideas and emotions, self-expression, and creativity, such as in literature and poetry. Conversely, the observed difference between genders in brain dominance Pattern (B) is not real and is attributed to chance, as this pattern pertains to the lower left hemisphere of the brain, related to organization, routine, management, and sensory experimentation, which can be present in both genders without gender preference.

For Brain Dominance Pattern (C), the results indicate female dominance in this pattern, is not due to chance but reflects real differences. Pattern (C) is associated with the lower right hemisphere of the brain, known for social behavior, prioritizing emotion, helping others, and easy integration into groups, traits more commonly associated with females due to their physiological and psychological characteristics. Regarding Brain Dominance Pattern (D), the results show a difference favoring females, but this difference is not real and can be attributed to chance. Thus, there is a convergence in gender preferences for Pattern (D), which represents the upper right hemisphere of the brain, responsible for creativity, imagination, and talent. These traits can indeed be found in both genders, as excellence, talent, and creativity are not exclusive to one gender, with many fields today offering opportunities for both genders based on equal opportunity and recognizing individual differences.

3.3 Results and discussion of the third hypothesis: the text of the third hypothesis was: There are differences in the choice of academic branch according to the variations in brain dominance patterns among second-year secondary school students. To address this, the frequencies of the sample individuals' brain dominance patterns were counted according to their choice of academic branches, as shown in Table 10.

Table 10: Shows the distribution of sample individuals according to brain dominance patterns and academic branches

Academic branches	Pattern				Total
	A	B	C	D	
Literature and Philosophy	03	24	61	10	98
Experimental Sciences	22	43	27	32	124
Foreign Languages	02	11	26	8	47
Mathematics	01	03	0	0	04
Management and Economics	01	17	01	04	23
Technical Sciences (Electrical Engineering)	07	10	00	06	23
Technical Sciences (Civil Engineering)	0	12	05	03	20
Technical Sciences (Mechanical Engineering)	01	03	0	04	08
Technical Sciences (Process Engineering)	01	04	02	01	08
Total	38	127	122	68	355

From Table (10), we observe that the largest number of students who chose the Literature and Philosophy branch have Brain Dominance Pattern (C), followed by Patterns (B, D, and A) in that order. The largest number of students who chose the Experimental Sciences branch have Brain Dominance Pattern (B), followed by Patterns (D, C, and A) in that order. For the Languages branch, most students who chose it have Brain Dominance Pattern (C), followed by Patterns (B, D, and A) in that order. In the Technical Mathematics branch, including Civil Engineering, Electrical Engineering, and Process Engineering, as well as Mathematics, Management and Economics, the majority of students who chose these fields have Brain Dominance Pattern (B), followed by Patterns (D, A, and C) in that order. However, for the Technical Mathematics branch specializing in Mechanics, the predominant pattern among students who chose it is pattern (D).

To determine whether these differences are real or due to chance, the Chi-square test for independence was used, as shown in Table 11:

Table 11: Shows the Chi-square value for independence to test the differences in brain dominance patterns among the sample individuals according to academic branches

Chi-square Value	Degrees of Freedom	P-value
91.472	24	0.000

From Table (11), we observe that the Chi-square value = 91.472 is statistically significant ($p < 0.001$), indicating that the differences observed are real and not due to chance. Thus, the third hypothesis has been verified, showing that: There are differences in the choice of academic branch according to the variations in brain dominance patterns among second-year secondary students.

Based on these results, we can conclude that the largest number of students who chose the Literature and Philosophy branch, as well as the Languages branch, are those with Brain Dominance Pattern (C). As previously mentioned, Pattern (C) is associated with the lower right hemisphere of the brain, known for its lack of precision, routine, control, thus better fitting the humanities and literary branches such as Literature and Philosophy and Languages, This aligns with the findings of most studies. Additionally, the largest number of students who chose the Experimental Sciences branch have Brain Dominance Pattern (B), as do those studying in the Technical Mathematics branch, Mathematics, and Management and Economics. Pattern (B) is associated with the lower left hemisphere of the brain, related to organization, realism, precision, routine, and sensory application. Experimental Sciences employ observational and experimental learning, thus aligning with Pattern (B), as well as Mathematics and Technical Mathematics branches, which involve logic and realism. The choice of these branches by students was not random but based on their brain dominance patterns.

This result, which shows the existence of differences in the choice of academic branches according to the variations in brain dominance patterns among students, consistent with studies by Mezyan and Zakai (2003) in Algeria, Saleh (2001) in U.S.A, And also the studies of both Nofal (2006) and Bawaneh et al. (2010) in Jordan; despite differences in sample and measurement scales with what was used in our study. While the result of this study differed from those of Taifour et al. (2021) in Jordan, which found no effect between the specialization variable and brain dominance patterns.

4. CONCLUSION

In this study, we aimed to investigate brain dominance patterns among second-year high school students and their relation to gender and academic branch variables. This study, which is focused on applying brain research in psychological and educational fields, as well as the principle of individual differences and competency-based approaches, has led to the following conclusions:

- The dominant brain pattern among the study sample is Pattern (B), associated with the left hemisphere of the brain. This finding is consistent with several studies, especially those in the Arab world, despite differences in samples and measurement tools.
- There are differences in brain dominance patterns attributed to gender, particularly with Pattern (A) favoring males and Pattern (C) favoring females, which aligns with the nature of each gender.
- There are differences in students' choices of academic branches according to their brain dominance patterns. While this is not entirely based on their brain preferences, it applies to the majority, confirming assumptions that student choice of academic branches and specializations is influenced by various factors, including brain dominance.

Based on these findings, we can suggest the following recommendations:

- Conduct studies at different educational levels and in various regions, and compare with the current study.
- Identify students' brain dominance patterns and use these results to enhance education and learning.
- Paying attention to creating a comfortable environment to achieve academic adaptation and psychological comfort for the learner by paying attention to his preferences and abilities, achieving what is compatible with them, and helping him to make the right choice of the appropriate academic branch for him.

- Train teachers in strategies and methods that stimulate both hemispheres of the brain among students.
- Emphasize various learning activities and extracurricular activities that stimulate both brain hemispheres, particularly the right hemisphere, by enriching and adapting curricula accordingly.
- Seeking to promote the principle of individual differences based on brain research and work on developing talent and creativity.

5. ***Bibliography List***

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