MEDICAL SCIENCE

Impact of brain hemisphericity on cognitive performances and attention in young healthy individuals: Cross-sectional observational study

Sonali Kumari[1], **Akanksha Saxena**[2*]

To Cite:
Kumari S, Saxena A. Impact of brain hemisphericity on cognitive performances and attention in young healthy individuals: Cross-sectional observational study. *Medical Science* 2023; 27: e297ms3120.
doi: https://doi.org/10.54905/disssi/v27i137/e297ms3120

Authors' Affiliation:
[1]Physiotherapist, Department of Physiotherapy, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, MM(DU), Mullana, Ambala, 133207, Haryana, India, Email-kolishsonali@gmail.com, ORCID ID- 0000-0003-3193-1126
[2]Assistant Professor, Department of Physiotherapy, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, MM(DU), Mullana, Ambala, 133207, Haryana, India, Email-akankshasaxena623@gmail.com, ORCID ID- 0000-0003-0852-7547

[*]**Corresponding Author**
Akanksha Saxena, Assistant Professor Department of Physiotherapy, Assistant Professor, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, MM(DU), Mullana, Ambala, 133203, Haryana, India, ORCID ID- 0000-0003-0852-7547
E-mail: akankshasaxena623@gmail.com

Peer-Review History
Received: 19 May 2023
Reviewed & Revised: 23/May/2023 to 08/July/2023
Accepted: 12 July 2023
Published: 18 July 2023

Peer-review Method
External peer-review was done through double-blind method.

Medical Science
pISSN 2321–7359; eISSN 2321–7367

ABSTRACT

Background: Understanding the style of cognition according to the brain dominance of students is necessary to keep them active and attentive. The study aims to check the cognitive performance and attention of young healthy individuals with right and left brain hemisphericity. *Methods:* This cross-sectional observational study was conducted at a physiotherapy institute from September 2022 to January 2023. 240 healthy young adults were recruited and informed consent was taken. Brain dominance of individuals was classified by Cognitive Style Brain Dominance questionnaire, Montreal Cognitive Assessment scale and sustained attention by Trail Making Test A, and selective attention by Trail Making Test B. *Result:* Out of the total recruited number of participants; 50.4% were male (n=121) and 49.6% were female (n=119). The varied brain dominance was seen as Right, Left, and Middle brain dominant to be 29.1%, 33.3%, and 37% respectively. The Spearman correlation was done for outcome measures which showed that medium positive relationship (ϱ=0.46) between left-brain dominant and sustained attention whereas a very strong negative correlation (ϱ=-0.90) between selective attention and left-brain dominant. Chi-square examines the study parameters and Mean comparison done by Friedman test which was statistically significant. *Conclusion:* There was significant relationship between left-brain dominance and sustained attention whereas a negative strong relationship between selective attention and left-brain dominance. Hence cognition does not depend upon varied brain dominance.

Keywords: Cognition, attention, brain, questionnaires

1. INTRODUCTION

The cerebral hemispheres of the individual brain have different processing properties and this asymmetry is called hemispheric lateralization (Corballis, 2009). The concept of brain hemisphericity refers to that every individual has a different way of cognition, hand dominance, lateralization of functions,

perception, attention, memory, thinking, emotion, and spatial ability (Weisi and Khaksar, 2012). There are numerous types of research done on hand dominance, lateralization of function, and spatial ability but no specific research shows cognitive difference mainly sustained attention in right and left hemispheric healthy young individuals.

Brain hemisphericity has relied on four main methods of assessing hemisphericity: Lateral eye movements, electrophysiological studies, questionnaires, and cognitive tests. Electroencephalogram, magnetic resonance imaging, and averaged evoked potential are different methods for electrophysiological studies. Questionnaires such as SOLAT, CSBD, and Hermann brain dominance instrument are used in hemispheric research because they are simple to administer (Beaumont et al., 1984). But no specific methods correctly showed the brain dominance of individuals.

In a study, the CSBD had been used as more reliable (Yacoub, 2017) and for assessing cognition MoCA, TMT A for sustained attention and TMT B for selective attention had been used (Ciesielska et al., 2016). Previous study demonstrates a constant and linear association between handedness and hemispheric language dominance in healthy people (Knecht et al., 2000). There was a study that correlate language and spatial processing of cognitive functions that are asymmetrically distributed in hemispheres with handedness in healthy populations (Flöel et al., 2005). Similar study was done to assess the correlation between brain dominance and academic achievements (Suresh et al., 2020).

But no definite evidence to differentiate the cognition and sustained attention in varied hemisphere-dominant young healthy individuals because the right hemisphere perceives and remembers tactile auditory and visual images; it's more efficient in progressing holistic, integrative and emotional information and the left hemisphere is associated with logical, mathematical, analytical thought and linear processing of information. So, our study aimed to access the varied brain dominance and their relation with cognition and sustained attention in healthy young adults. We hypothesized there may or may not be a relationship between brain hemiphericity, cognition, and sustained attention in healthy young adults.

2. MATERIALS AND METHODS

Participants

The study was a cross-sectional observational study conducted in a renowned Physiotherapy institute. Although a correlation study requires a minimum sample size between 50 and 100, after considering the proportion value from the previous study (Mansour et al., 2017). The sample size was estimated to be 200 and present study screened 260 individuals of these, 240 individuals were recruited from September 2022 to January 2023. The ethical was approved by Institutional Ethical Committee with a registration number IEC/MMDU/2222 and was also registered on Clinical trials with registration CTRI/2022/09/046051. Guidelines of the Declaration of Helsinki and National Ethical Guidelines for Biomedical and Health Research involving Human participants given by the Indian Council of Medical Research were followed.

The participants which were included in the study are both male and female healthy young adults of the age group 18-25 years, (Grossi et al., 2010) who understand English, (Leonard and Abramovitch, 2008) are alert and attentive, and provide informed consent to participate in the study. We exclude individuals with a history of any cognitive impairment (Leonard and Abramovitch, 2018) and visual impairments, difficulty in reading, and drug use for cognitive behaviour (Biederman et al., 2008).

Procedure

The individuals were screened by selection criteria and those who met the criteria were recruited for study and collection of data was done between September 2022 to January 2023. The demographic details of individuals were recorded i.e., name, age, gender, body mass index (BMI), hand dominance, course, and year of enrolment. Before starting the procedure, participants were explained the significance of the study to gain confidence.

The participants were asked to fill out the CSBD that categorizes individuals into right, middle, and left-brain dominant. The total score of the questionnaire is 21 in 0-8 classified left brain dominant, 9-11 middle brain dominant, and 12-20 right brain dominant (Rathod et al., 2019). The internal consistency of the tool has been measured by the Kuder-Richardson equation which is 0.821 (Nithyanantham and Regis, 2021). Afterward, to test cognition and attention MoCA, TMT A and B have been performed. Figure 1 represents the study flowchart which is according to STROBE guidelines.

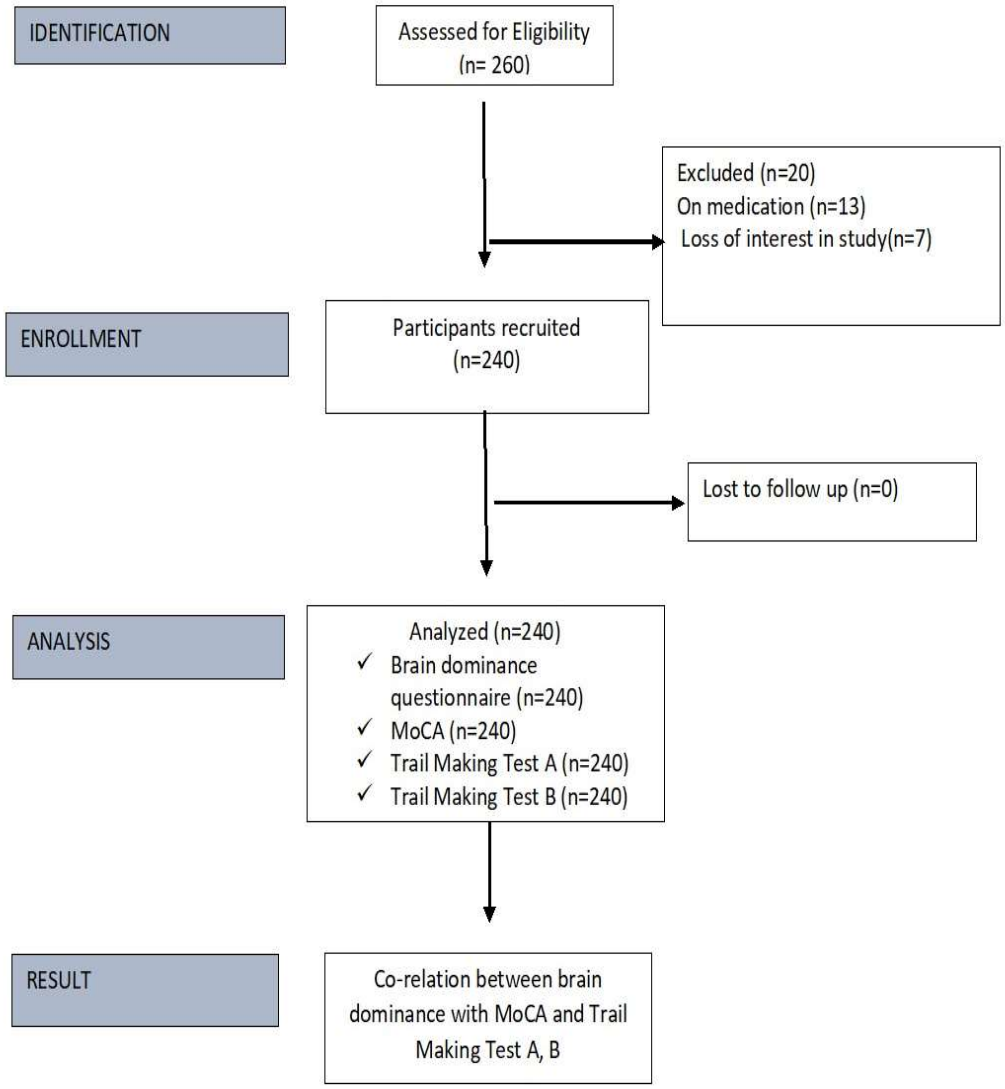

Figure 1 Flow diagram of the study

Statistical analysis

The level of significance was set at < 0.05. To determine the normality Kolmogorov-Smirnov test has been used. The results were interpreted in form of frequencies, spearman correlation, pie charts, tables, and graphs. The demographic data was found to be not normally distributed ($p < 0.001$); hence descriptive statistics were demonstrated in the median and interquartile range. For continuous variables, the spearman correlation coefficient was calculated and Chi-square for study parameters. For comparison of mean difference between varied brain dominance and lateralized functions Friedman test has been used.

3. RESULTS

Two hundred forty young healthy individuals of mean age were included in the present study, to confirm cognition and attention according to brain dominance. The median age for healthy young individuals was 21 years ($p<0.001$). The male exceeds the female participants in the study. Right-handed out numbered the left-handed dominant due to the prevalence rate. The listwise brain dominance participants were for right (n=70), middle (n=90), and left (n=80). However, Figure 2 shows the frequency distribution of brain dominance among the physiotherapist students were right-brain dominants (29.17%), middle-brain dominants (37.50%) and left-brain dominants (33.33%).

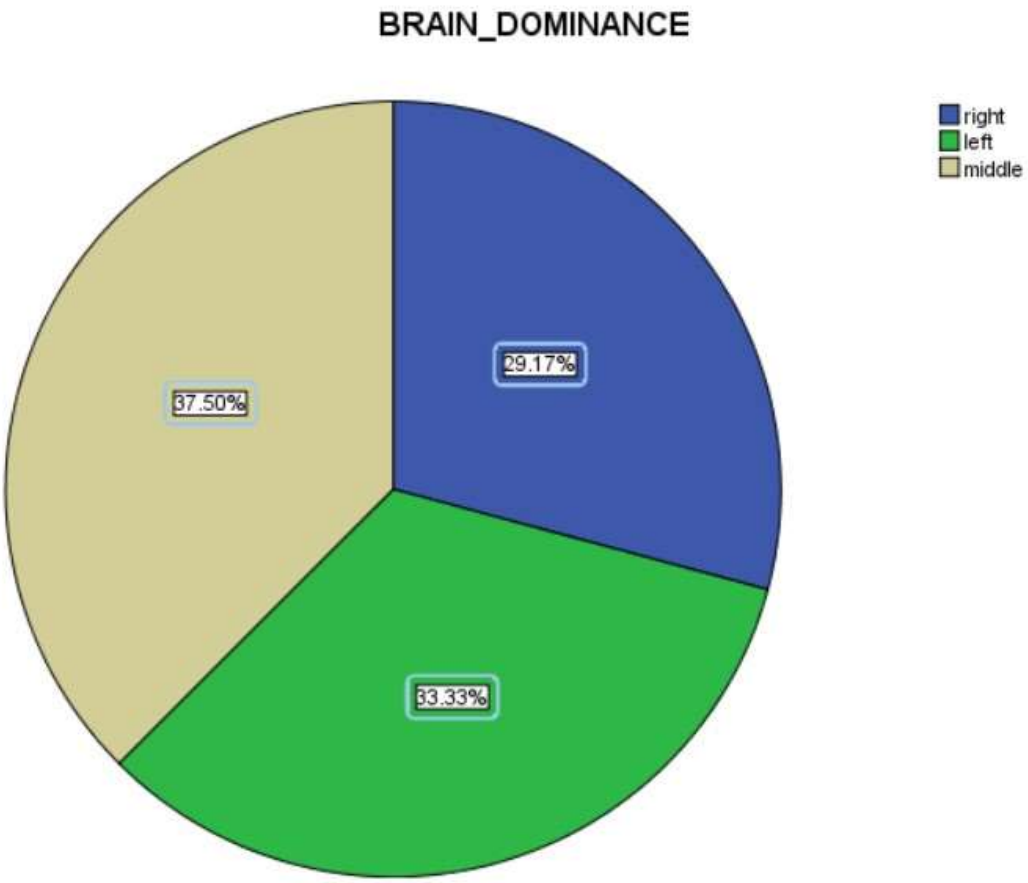

Figure 2 The pie chart depicting the frequency distribution of varied Brain dominance

The Anthropometric measures were given in Table 1 as the median and interquartile range. Spearman coefficient for correlation and chi-square for study parameters difference had been ruled out. In Table 2 correlation (ϱ), for outcome measures was ruled out which showed that medium positive relationship (ϱ=0.46) between left-brain dominant (CSLBD) and sustained attention (TMT A) whereas a very strong negative correlation (ϱ=-0.90) between selective attention (TMT B) and (CSLBD) left-brain dominant. Right brain dominance with sustained attention also showed a strong negative correlation (ϱ=-0.64) and the rest further all show a weak positive and negative correlation.

Table 1 Represents Anthropometric Data at the baseline

Demographic Profile	Median (95% CI)	Range	p-value
Age (years)	21 (21.76-21.51)	25-18	<0.001
Weight (kg)	55 (60.44-67.83)	95-45	<0.001
Height (cm)	165 (162.91-167.50)	182-146	<0.001
BMI (kg/m^2)	20.7 (20.66-21.45)	33-16	<0.001
Brain dominance	2 (1.98-2.19)	3-1	<0.001
Cognitive style questionnaire	11 (10.52-11.40)	18-4	<0.001

Table 2 Represents the correlation between variables

CSBD	MoCA (ϱ)	TMT A (ϱ)	TMT B (ϱ)
Right brain dominance	0.085*	0.054*	-0.64
Middle brain dominance	-0.086	-0.191	-0.269
Left brain dominance	-0.120	0.42*	-0.90

CSBD- Cognitive style brain dominance questionnaire, MoCA- Montreal cognitive assessment, TMT A and TMT B- Trail making test A and B.
ϱ=Spearman correlation coefficient (*- represents positive correlation)

In Table 3 chi-square has been used to find the significance of the study parameters for categorical variables to find an association between two and more groups among young healthy adults. When a comparison of the association between gender, brain dominance, cognition level, and attention was calculated it shows a significant value (p=0.01). Association between CSBD and MoCA for attention has been ruled out which shows significant value. TMT A for sustained attention and TMT B for selective attention have been found which depicts that there was an association between brain dominance and attention of healthy young adults.

Table 3 Represent Chi-square difference between CSBD questionnaire and other study parameter. It shows significant p value (<0.05)

CSBD (cognitive style brain dominance questionnaire)			
Variables	X^2	df	p-value
MoCA	2.64	140	
TMT A	1.91	1204	
TMT B	1.71	1078	0.01*

* Significant association between variables.
CSBD- Cognitive style brain dominance questionnaire,
MoCA- Montreal cognitive assessment,
TMT A and B- Trail making test A and B
X^2=Chi- square, df=Degree of freedom

Table 4 and Figure 3 show a comparison between Right, Middle and Left-brain dominance with lateralized functions i.e., cognition, sustained and selective attention. Right and left hemisphere scores when compared with cognition, sustained and selective attention showed statistically significant difference (p<0.05) but middle brain dominant when compared with lateralized functions showed non-significant difference (p>0.05).

Table 4 Comparison of varied Brain Dominance with Lateralized functions using Friedman test

Brain dominance	MoCA Mean rank	TMT A Mean rank	TMT B Mean rank	p-value
Right dominant	2.33	1.59	2.09	0.00**
Left dominant	2.22	1.94	1.84	0.02**
Middle dominant	2.14	1.91	1.95	0.27

** Significant difference at the 0.05 level

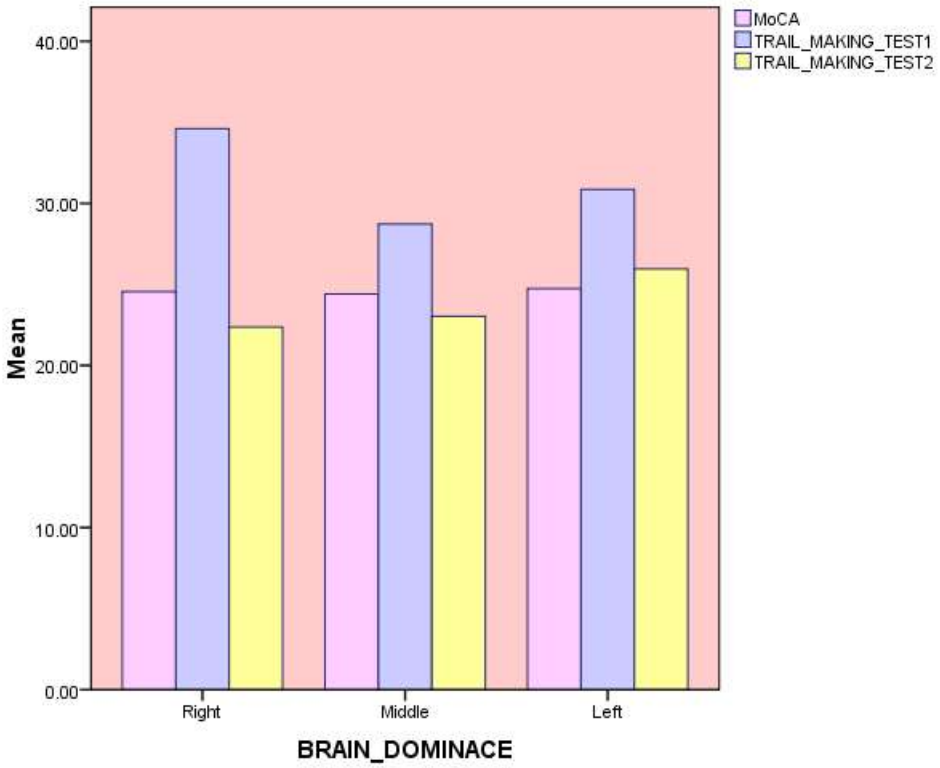

Figure 3 Bar graph displaying comparison of varied brain dominance with lateralized functions

4. DISCUSSION

In the current study, we examined hemispheric lateralization, which describes how one cerebral hemisphere processes information more effectively than the other and suggests that some functions are differentially represented in the two sides of the brain. Hemispheric lateralization is thought to benefit individuals by increasing brain efficiency and populations as a whole by promoting social coordination and constructive actions among individuals (Guillén et al., 2019). Here, we focus on cognition and sustained attention—core functions that underlie much everyday life tasks and explore the impact of cerebral dominance on their regulation. This study emphasizes the effect of brain dominance on cognition and attention in young adults.

Many other studies correlate brain dominance with other lateralization functions. There was study on left-brain dominance on higher secondary students and results showed that left brain dominance individuals have moderate relationship between academic achievements and dominance (Nithyanantham and Regis, 2021). The correlation (ϱ), showed medium positive relationship between left-brain dominant (CSLBD) and sustained attention (TMT A) whereas a very strong negative correlation between selective attention (TMT B) and (CSLBD) left-brain dominant. Right brain dominance with sustained attention also showed a strong negative correlation and the rest further all show a weak positive and negative correlation.

Previous literature rules out that hemispheric asymmetries and individual differences for language and spatial attention which indicate that handedness regulates behavioral performances in tasks. Verbal task are performed better by right-handed individuals and non-verbal task were done by left-handed individuals (O'Regan and Serrien, 2018). Hence, this study focuses on the brain dominance and their regulation on attention and cognition which shows statistically linear relationship between hemispherical brain dominance and the student's mental actions or processing of acquiring knowledge and understanding through thought, experience, and sense.

According to the present study, students who are right and left-brain dominants showed significant difference between cognition, selective and sustained attention which denotes that right and left hemispheric have different way of style towards cognition, sustained and selective attention but no significant difference between middle hemispheric dominant and lateralized functions. A pervious study performed among MBBS and BDS students who correlate the relationship between academic performances with hemispheric score which showed non- significant mean difference. Despite middle brain hemisphere this study showed significant mean difference between right and left-brain hemisphere with lateralized functions. As cognition and attention plays vital role in academic achievements which depend upon hemispheres of brain (Khanal et al., 2023).

A positive relationship between cognitive styles was not found although Chi-square has been used to examine the study parameters of brain dominance, cognition, selective and sustained attention which shows there is a significant association between them. Real-world attention-related tasks require the ability to ignore a range of distractions and prevent attention from shifting to other activities that differ from individuals' perspectives. Previous correlation analysis demonstrates that the undergraduates' reading skills, writing skills, and speaking abilities were favourably connected with their hemisphere dominance (Nair and Lee, 2016).

These all abilities are part of cognition and hence, the current study concludes that there is no direct relationship between varied brain dominance and sustained attention a core part of cognition. According to studies that examined the pattern of information processing in children based on hemispheres, boys had right hemisphere preference and girls had left hemisphere preference (Iqbal-Hydrie et al., 2021). Other literature investigates the hemispherical brain dominance and its relationship with academic achievements where findings were right brain dominants have significant difference in their grade point (Suresh et al., 2020).

Brain dominance and hand preferences showed right handers demonstrate left brain dominance as they are more analytical and logical. Left-handed students have right brain dominant who have character of above average ability in mathematics and problem solving (Joven et al., 2020) but this study highlights the importance of understanding varied brain dominance in young adults, it would assist teachers in implementing different teaching methods to improve and facilitate student learning.

We attempted to perform the study in a medical setting because there is little literature on the correlation between brain hemisphere and lateralization of functions, as previous studies correlate the lateralization of function according to the handedness of individuals. We evaluated the participants' performance based on a single test, although longitudinal measurement of cognition and attention progress would have been more accurate. The sample size of the study was small according to a cross-sectional observational study, more outcome measures can be included, and results are influenced by varied dominance, hence further research can be done with a wide age group with other domains.

5. CONCLUSION

The study was done to find out the varied hemisphere dominance among physiotherapy young adults and the hemispheric relationship between two core lateralized functions in the brain- cognition, and attention. This showed that the cognition and attention of individuals doesn't depend upon their brain dominance as it varies among individuals.

Abbreviation

CSBD- Cognitive style of brain dominance
TMT A and B- Trail making test A and B
MoCA- Montreal cognitive assessment scale

Acknowledgment

We thank the participants who were all contributed samples to the study.

Author Contribution

Primary author- Sonali Kumari, PG research project who contribute in data collection and production of result. Secondary author- Akanksha Saxena, who guided the study.

Ethical approval

The study was approved by Institutional Ethical Committee with a registration number IEC/MMDU/2222.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

REFERENCES AND NOTES

1. Beaumont JG, Young AW, Mc-Manus IC. Hemisphericity: A critical review. Cogn Neuropsychol 1984; 1(2):191–212.
2. Biederman J, Seidman LJ, Petty CR, Fried R, Doyle AE, Cohen DR, Kenealy DC, Faraone SV. Effects of stimulant medication on neuropsychological functioning in young adults with attention-deficit/hyperactivity disorder. J Clin Psychiatry 2008; 69(7):1150–6. doi: 10.4088/jcp.v69n0715
3. Ciesielska N, Sokołowski R, Mazur E, Podhorecka M, Polak-Szabela A, Kędziora-Kornatowska K. Is the Montreal Cognitive Assessment (MoCA) test better suited than the Mini-Mental State Examination (MMSE) in mild cognitive impairment (MCI) detection among people aged over 60? Meta-analysis. Psychiatr Pol 2016; 50(5):1039–52. doi: 10.12740/PP/45368
4. Corballis MC. The evolution and genetics of cerebral asymmetry. Philos Trans R Soc Lond B Biol Sci 2009; 364 (1519):867–79.
5. Flöel A, Buyx A, Breitenstein C, Lohmann H, Knecht S. Hemispheric lateralization of spatial attention in right-and left-hemispheric language dominance. Behav Brain Res 2005 ; 158(2):269-75. doi: 10.1016/j.bbr.2004.09.016
6. Grossi G, Savill N, Thomas E, Thierry G. Posterior N1 asymmetry to English and Welsh words in Early and Late English-Welsh bilinguals. Biol Psychol 2010; 85(1):124-33. doi: 10.1016/j.biopsycho.2010.06.003
7. Guillén M, Monferrer-Tirado D, Moliner M. The Relation between Learning Styles according to the Whole Brain Model and Emotional Intelligence: A Study of University Students. Estud Sobre Educ 2019; 26:85-111.
8. Iqbal-Hydrie MZ, Zulfiqar Hyder Naqvi SM. Assessing learning styles of medical students using Kolb's learning style inventory and their association with preferred teaching methodologies. J Pak Med Assoc 2021; 71(4):1157-1161. doi: 10.47391/JPMA.1437
9. Joven MML, German JD, Buan MLO, Carreon ABG, Ochoa MJ. Correlating brain dominance and hand preference to academic tracks: A case for senior high school students (SHS) in the Philippines. Proc Int Conf Ind Eng Oper Manag 2020; 1791–801.
10. Khanal L, Shah S, Koirala S, Rimal J, Adhikari BR, Baral D. Relationship between Hemispheric Preference Score and Academic Performance among Preclinical Medical Students Studying Medicine and Dentistry. Int J Appl Basic Med Res 2023; 13(1):16-22. doi: 10.4103/ijabmr.ijabmr_440_22
11. Knecht S, Dräger B, Deppe M, Bobe L, Lohmann H, Flöel A, Ringelstein EB, Henningsen H. Handedness and hemispheric language dominance in healthy humans. Brain 2000; 123 Pt 12:2512-8. doi: 10.1093/brain/123.12.2512
12. Leonard K, Abramovitch A. Cognitive functions in young adults with generalized anxiety disorder. Eur Psychiatry 2019; 56:1–7.
13. Mansour EA, El-Araby M, Pandaan IN, Gemeay EM. Hemispherical Brain Dominance and Academic Achievement among Nursing Students. IOSR J Nurs Health Sci 2017; 06(03):32–6.
14. Nair MA, Lee P. An Exploration of the Learning Style Among Undergraduate Nursing Students From An Indian Perspective. IOSR J Nurs Health Sci 2016; 5(5):1–4.
15. Nithyanantham V, Regis X. A Study on Left-Brain Dominance of the Higher Secondary Students. Eurasia Proc Educ Soc Sci 2021; 21:48–54.
16. O'Regan L, Serrien DJ. Individual Differences and Hemispheric Asymmetries for Language and Spatial Attention. Front Hum Neurosci 2018; 12:380.
17. Rathod RM, Suresh V, Patel B. A Descriptive Study to Assess the Cognitive Style among Teachers Working in Selected Schools of Vadodara (With a View to Improve Cognitive Process). Int J Nurs Educ 2019; 11(4):113–6.
18. Suresh V, Poornima C, Anjana K, Debata I. Assessment of brain dominance and its correlation with academic achievement among medical students: A cross-sectional study. Arch Ment Health 2020; 21(1):25–9.
19. Weisi H, Khaksar Z. The Effect of Text-Generation on EFL and ESL Learners. Int J Engl Educ 2012; 4(2):1–15.
20. Yacoub MH. A Training Programme Based on Information Processing in View of Cerebral Hemisphere to Enhance Self-Regulation Skills and Its Effect on Reading Comprehension among a Sample of Preparatory School Pupils with English Learning Disabilities. Ethiop J Health Sci 2017; 21(9):43-66.