

The Relationship between Problem-Solving Ability (Visual-Spatial) and Handedness Among high school students in Ghorveh city

Abstract

The purpose of the study was to examine the relationship between problem-solving ability (visual-spatial) and handedness in first-grade male students of the high school in Qorveh. The study was applied in terms of the purpose and correlational with the structural equation modeling (SEM) in terms of method. The population was all male students in the first grade of high school Qorveh in the academic year 2014-2015, who were 830 people, according to the announcement of the education administration of Qorveh. The sample size was determined as 220 people using Cochran's formula. Chapman Handedness Inventory and Kohs block test were used to collect data. For data analysis, SEM was used in SmartPLS. The reliability coefficient of variables, according to Cronbach's alpha, was 0.916 for handedness and 0.665 for problem-solving, showing acceptable reliability. The reliability coefficient of the variables for composite reliability was 0.929 for the handedness and 0.669 for solving the problem, showing acceptable reliability. The average variance extracted for the handedness was 0.611 and 0.475 for problem-solving, showing acceptable validity values. The findings indicated that handedness had no direct effects on students' problem-solving.

Keywords: *Problem-solving ability, handedness, male students, high school*

Dr. Reza Rahimi

*Department of Psychology, Payame Noor University, Tehran, Iran.
r_rahimi@pnu.ac.ir*

Introduction

Problem-solving has been considered one of the important educational goals throughout the history of education, with acquiring the ability of students to solve problems as one of the demands of teachers and parents. Different psychologists and theorists have always emphasized the significance of activities associated with problem-solving in creating useful and effective learning. By definition, when the learner faces a situation, s/he cannot give a correct answer to that situation quickly using the information and skills he has at that moment, or when he has a goal and still has a way to reach it, we say that he is facing a problem if he has not found it. Given the definition of the problem, problem-solving could be defined as the recognition and application of knowledge and skills that lead to the learner's correct response to the situation or his reaching his desired goal. Hence, the basic element of solving the problem is the application of previously learned knowledge and skills in new situations (Seif, 2021). Solving the problem of learning is called a higher-level rule in Gagne's theory (1985). According to this theory, the learner creates a higher-order rule by combining simple rules, which leads to problem-solving. Thus, in solving the problem, the person's previous learning, especially the rules or principles already learned, must be combined in a new manner. One must remember that in solving the problem, one's previous learnings, especially the principles that result from their combination, must be combined in a new manner. In other words, solving a problem is not only knowing information, concepts, or principles and putting them together but also the learner must discover new ways of combining previous knowledge that results in solving the problem (Seif, 2021).

We have all faced people who can do some things with their right hand, some activities with their left, and other things with

both hands. In recent years, this topic has made researchers active in neuropsychology think and has done a lot of studies in this regard. Neuropsychology is an interdisciplinary approach that studies the relationship between brain function and behavior and higher psychological processes (Kolb & Whishaw, 2022). In two symmetrical systems of the body, dominance or superiority of one over the other is called lateral superiority. Regarding this, one can talk about the superiority of one hand over the other, the superiority of one eye, and the superiority of one ear or leg. Handedness is defined as the dominant preference for one hand in efficiency tests performed with one hand (Cavill & Brayden, 2003). Left-handers have been and are in the minority in all human populations (Raymond & Pontier, 2004). They form about 10% of the population and are more common in men than in women (Gilbert and Wysocki, 1992), and the frequency of right superiority in the general society has been estimated at about 90% (Annet, 2020). Psychologists, especially neuropsychologists, consider handedness to be an indirect index of hemispheric dominance or lateral dominance (Pinel, 2006 and Bishop, Ross, Daniels & Bright, 1996), meaning that the left brain is dominant in right-hemisphere-dominant people and the right hemisphere in left-handed (Kiroskari, Salemlin, and Harry, 2006).

Ghayas & Adil (2021) examined the effect of handedness on intelligence in 150 students. The instrument for measuring intelligence in this study was Raven's standard progressive matrices test. The study findings indicated that the intelligence of left-handed participants was significantly higher than the intelligence of right-handed, and the time spent by right-handed participants was significantly higher than that of left-handed participants. Ruebeck, Harrington & Moffitt (2007) found a positive and significant relationship between

handedness, mental abilities, and the level of education of left-handed men. Kalpana & Mirdula (2007) stated that left-handers are different from right-handers in the way they think and pay attention to many factors in the situation, which means that left-handers use different management methods. Denny & O'Sullivan (2020) stated that left-handers are different from right-handers in their thinking and attention to several factors in the situation, meaning that left-handers use different management methods. Brenneman, Scott Decker, Joel Meyers & Johnson (2008) examined the relationship between handedness and reading skills, and cognitive processes. Regression analysis indicated a proportional relationship between handedness and reading skills, along with handedness and auditory working memory. Randerson (2001) revealed that right-handed with left-handers in their families perform better in recalling and memory tasks than right-handed people whose all families are exclusively right-handed (McManus, 2022).

A large-scale study (255,200 subjects) by Peters et al. (2006) indicates that those who consistently use one hand perform better in tasks of mental rotation and verbal fluency than those who use two. have disadvantages. Krommydas et al. (2004) revealed that the sensitivity of the fetus to testosterone increases the probability of the simultaneous presence of left predominance and bronchial asthma. In his study entitled gender differences in mental and spatial rotation, Parsons (2004) showed that girls and boys are different in pencil-paper tests. Casey, Pezaris & Nuttall (1992) showed that the spatial ability of left-handed people is more than that of other people. Denny (2008) studied the issue that the relative skill of the hands is a suitable predictor for academic abilities stating that the findings of the study are based on the existence of a relationship between cognitive abilities and the relative skills of the hands, the existence of equal skills in the left and right hands are associated with cognitive defects, yet the complex causes of this relationship are still not clear.

Myers (2022) indicated that the perceptive power of left-handers is more specialized than right-handers due to the dominance of the right hemisphere. McManus (2022) showed that left-handers have more perceptive power compared to right-handers. Castro-Schilo & Kee (2010) examined the relationship between emotional intelligence and right hemisphere dominance of 122 students, and the results showed that 4.5% of the variance of right hemisphere dominance was for facial emotion processing. Dana et al. (2020) found a significant relationship between creativity and the right hemisphere of the brain. Mihov et al. (2010) indicated that the right hemisphere of the brain is more active in creative people. Barnett & Corballis (2021) showed that left-handed people perform more creative activities. McCrea (2010) and Khosrovizadeh and Teimurzadeh (2010) stated that right-handers are more inclined to convergent thinking and left-

handers are more inclined to divergent thinking. Khaleghi Delavar and Alipour (2013) showed that happiness and humor are lateralized in the brain in such a way that the left hemisphere is responsible for processing happiness and the right hemisphere is responsible for processing humor. Alipour and Saleh Mirhassani (2011) indicated a significant difference between left-handed and right-handed people in general intelligence, verbal intelligence, and three sub-scales of verbal intelligence (information, number span, and comprehension) and some components of practical intelligence (completing and organizing pictures and designing cubes) and the overall and verbal intelligence of left-handed people in this research was more than that of right-handed people. In another study, the relationship between family dominance and mental rotation ability was examined, with the findings confirming that the effect of family dominance on the ability of mental rotation is significant and the effect of family dominance (based on gender) on the ability of mental rotation indicate significant differences (Alipour and Baghban Porshokuhi, 2008).

Alipour and Mardani Rad (2013) revealed that the majority of left-handed subjects rotate to the right, and the majority of right-handed subjects rotate to the left, showing a significant difference in handedness and rotation. Hacken et al. (1971) showed a lot of evidence that left dominance is more common among children who have intellectual disabilities and neurological disorders (Kyani, 2019). The lateral dominance functions of the brain vary, and the amount of fusion and left superiority (in total fine and gross movements) is more in mentally retarded children (ibid). In his study on candidates participating in the university entrance exam for five years (1993 to 1998), Nowrouzian (2007) showed that left-handed students had more chances to pass mathematics than right-handed students, and this probability was more for boys than for girls. In a study entitled comparing the social intelligence and emotional intelligence of students according to their handedness, Selagi and Alipour (2012) indicated that right-handed students are more self-aware, alert, and have higher social skills.

Zare and Amirpour (2012) revealed that the superior left-handed students got significantly higher scores in the rumination strategy, but the average scores of the superior right-handed students in the strategy of refocusing and planning had a significantly higher frequency of dominant left higher in boys. In another study, the relationship between handedness and the academic progress of middle school students was examined where the comparison of the overall mean scores of right-handed and non-right-handed students revealed that their academic progress scores insignificantly differed from each other (Alipour and Kalantarian, 2012). Alipour and Akhoundi (2011) indicated that the top left-handed students scored higher in judicial and general thinking

styles than the top right students; however, right-handed performed better in executive thinking style and detailed thinking style. Shafii and Alipour (2013) examined the effect of children's handedness on the lateralization of facial emotional processing, showing that the left-handed subjects showed right visual field bias. It was because they perceived the emotional faces presented in the right visual field much faster than the left visual field, and this bias was significant for the angry face. Right-handed subjects indicated no effects of emotional processing lateralization.

A review of the literature and the combination of the numerical results of different studies on handedness in autism indicate that 52% of children with autism do not have a specific hand preference or are left-handed (Springer, 2022). Many studies state that the prevalence of left-handedness and the level of artistic abilities and visual-spatial skills in autistic children is higher than that of the normal population. Salafeh (1997) refers to an autistic girl named Nadia, who is also left-handed at the age of 3.5 and has drawn very beautiful and delicate designs with remarkable details. When she was treated, his skills deteriorated to some extent, but it is unclear whether this deficiency is due to the continuation of the treatment or the result of his maturity (Springer, 2022). Morfit & Weekes (2001) indicated that autoimmune diseases are more prevalent in left-handed people, and those who have at least one autoimmune disease show more severe left-handedness than those who do not. Crow (1996) claims that psychotic people are more left-handed or ambidextrous compared to normal people as well as non-psychotic psychiatric patients. Ambidextrous and left-dominant children are more likely to suffer from psychosis in the future, and brain asymmetry in the temporal region is associated with left dominance (Shapleske, 1999).

Different studies confirm the relationship between high levels of androgenic hormones during the embryonic period and increased skill in solving visual-spatial problems, such as the study of Anders & Hampson (2005) and the results of Resnik et al. (1986) that are consistent with the hypothesis that the effects of androgenic hormones during the embryonic period on the development of the ability to solve spatial problems. Krommydas et al. (2004) indicated that the sensitivity of the fetus to testosterone increases the possibility of the simultaneous presence of left predominance and bronchial asthma. Based on the belief of some researchers, if, contrary to the child's inner desire, we push him to the right-hand side, this can create unpleasant conflicts in the child and may lead to serious disorders such as stuttering and feelings of inferiority (Dadsetan, 1999). On the other hand, as the results on handedness indicate many differences of opinion in this regard, the results of the present study can lead researchers to conduct more studies in this regard. Given the points stated, the purpose

of the study is to examine the relationship between problem-solving ability (visual-spatial) and handedness in male students in the first grade of high school in Qorveh.

Methods

The study was applied in terms of the purpose and correlational with SEM in terms of method. The population was all male students in the first grade of high school Qorveh in the academic year 2014-2015, who were 830 people, according to the announcement of the education administration of Qorveh. The sample size was determined as 220 people using Cochran's formula. Using Cochran's formula, the sample size was 220 people. The samples were selected from among the population using the multi-stage cluster sampling method so that four high schools were randomly selected from among the male high schools in Qorveh and two classes were randomly selected from among these schools, and tests were conducted on the students of these classes (5 classes had 28 people, two classes had 27 people and 1 class had 26 people).

Measuring tools

Chapman Handedness Inventory

The questionnaire has 13 items, the materials of which are extracted from among the best materials of authentic questionnaires, during which people are asked to specify which hand they use to do activities like writing, painting, throwing, hammering, brushing, wiping with an eraser, striking a match (holding a matchstick), shaking an ink bottle, using a spoon, scissors, knife and screwdriver, and opening and closing a bottle cap. The subjects' answers to each question are determined based on choosing one of the three options: right hand (score 1), both hands (score 2), and left hand (score 3). Hence, the scores fluctuate between 13 (completely superior right) to 39 (completely superior left). The subjects with a score of 13 to 17 are classified as right dominant, and subjects with a score of 18 to 39 are classified as non-right dominant (left dominant and ambidextrous). After conducting this test on 2931 subjects, Chapman and Chapman (1987) reported 0.96 internal consistency of this questionnaire, 0.97 test-retest reliability, and 0.83 correlation with the behavioral assessment of dominance. This test has been standardized in Iran by Alipour (2006) for middle school students in Tehran. He reported the Cronbach's alpha of this questionnaire as 0.94, the split-halves correlation as 0.97, and the retest reliability as 0.92. This test has been used in different studies, such as Mohr, Thut, Landis & Brugger (2003).

Kohs block test design

The test materials consist of two parts: A) 16 wooden cubes with exactly the same dimensions where four colors of yellow, red, white, and navy can be seen, and B) 17 various geometric pictures arranged from simple to hard. The scoring of the test depends on two variables: the time spent and the accuracy of the pictures created. Hutt's study in 1932 on a large group of

children between 9 and 11 years old showed that the Kohs test is capable of classifying children based on the functional degree of their mental activities, especially in measuring visual and spatial skills. A similar study was conducted by Dubus in 1975 on 609 children aged 5 to 9 years and once again confirmed the results of Hutt's study. In this study, the internal consistency of this test was 0.91, and its test-retest reliability was 0.89 (Reio et al., 2004).

Other studies report a correlation between 0.60 and 0.80 between the Kohs test and the Stanford-Binet test (Bahrami, 2003). Kohs block design tests are valid tests for measuring visual and spatial skills and are widely used for visual-spatial skills (Reio et al., 2004). The examiner helps the subject in making the first and second pictures, if necessary, explains what is required for this task, and waits for the square to be made. A time limit is allowed for each picture. If he makes the picture within the needed time, he will be given points according to the relevant table, and if the time of making pictures exceeds the allowed time, no points will be given to the subject. In pictures 3 to 17, the examiner does not give any help to the test. The maximum time needed to make each

picture is written both on the picture itself and on the grading sheet. The test is stopped after three consecutive failures. In scoring, the answers of the practice test are not considered, and each picture must be made in the required time, and any picture not made completely correctly at the end of the required time will not get a score. When the subject succeeds, he can make the presented picture completely; the score he gets is different according to the time spent. The number of points and the time required to make different pictures are different. The scoring method and the time required for different pictures are recorded on the grading sheet. During the test administration, the examiner notes the time taken to make it on the number of each picture. From the time spent by the subject or equal to it, it is found that the number written on the left side of this time will be the number of points that should be given to the subject. Besides using the central and dispersion indices according to the measurement level of the variables, the SEM was used in the study to analyze the data in SmartPLS.

Results

The descriptive results of the variables are given in Table (1).

Table 1. Description of the variables

Variables	Mean	Mean standard error	Min.	Max.	Scope of changes	Variance	SD	Kurtosis	Kurtosis SD	Kurtosis	Standard error of skewness
Handedness	15.87	0.304	13	35	22	20.276	4.503	2.871	0.164	7.670	0.327
Problem-solving	81.88	1.053	51	132	81	243.953	15.619	1.383	0.164	2.294	0.327

The data in Table (1) indicate that the average score of the subjects in handedness is 15.87, and it is standard deviation is

4.50, and in problem-solving, it is 81.88, and a standard deviation is 15.62.

Table 2. Kolmogorov-Smirnov and Shapiro-Wilk test results for the normality of the distribution of the variables

Variables	Kolmogorov-Smirnov	Degree of freedom	Sig.	Shapiro-Wilk	Degree of freedom	Sig.
Handedness	0.330	220	0.0001	0.565	220	0.0001
Problem-solving	0.143	220	0.0001	0.872	220	0.0001

The results of the Kolmogorov-Smirnov test show that the distribution of the variable data of handedness ($p < 0.01$ and $Z = 0.330$) and problem-solving ($p < 0.01$ and $Z = 0.143$) is not

normal. Hence, SmartPLS software was used for modeling and testing research hypotheses.

Table 3. Indices of the handedness measurement model

Item	b	t	p
1	0.928	44.234	$p < 0.01$
2	0.839	22.548	$p < 0.01$

3	0.734	13.509	p < 0.01
4	0.661	11.080	p < 0.01
5	0.615	1.142	p < 0.01
6	0.714	12.762	p < 0.01
7	0.443	3.871	p < 0.01
8	0.763	14.962	p < 0.01
9	0.648	9.210	p < 0.01
10	0.519	4.659	p < 0.01
11	0.642	8.672	p < 0.01
12	0.782	11.871	p < 0.01
13	0.847	20.707	p < 0.01

The data in Table (3) indicate that all items of the questionnaire have a significant effect in measuring handedness.

Table 4. Indices of the problem-solving measurement model

Item	b	t	p
1	0.376	0.928	N.S.
2	0.360	0.714	N.S.
3	0.491	0.443	N.S.
4	0.362	0.763	N.S.
5	0.361	0.648	N.S.
6	0.376	5.695	p < 0.01
7	0.374	5.701	p < 0.01
8	0.484	6.121	p < 0.01
9	0.432	6.215	p < 0.01
10	0.392	0.519	N.S.
11	0.414	0.642	N.S.
12	0.494	0.782	N.S.
13	0.417	0.847	N.S.
14	0.454	0.839	N.S.
15	0.373	0.734	N.S.
16	0.373	0.661	N.S.
17	0.638	0.615	N.S.

The data in Table (4) show that items 6, 7, 8, and 9 of the coefficient questionnaires have a significant effect on measuring problem-solving.

Table 5. Cronbach's alpha values

Variables	Cronbach's alpha	Composite reliability
Handedness	0.916	0.929
Problem-solving	0.665	0.669

The reliability coefficient of variables, according to Cronbach's alpha, was 0.916 for handedness and 0.665 for problem-solving, showing acceptable reliability. The reliability coefficient of the variables based on composite reliability was

0.929 for the handedness and 0.669 for solving the problem, showing acceptable reliability.

Table 6. Mean values of extracted variance

Variables	AVE	Composite reliability	R ²
Handedness	0.611	0.611	—
Problem-solving	0.475	0.475	0.602

The average variance extracted was 0.611 for the handedness and 0.475 for solving the problem, showing acceptable validity values. The coefficient of explanation was 0.339 for cognitive styles and 0.602 for problem-solving, indicating that the values stated are average and acceptable.

Table 7. The effect of variables on problem-solving

Variables	Direct effect			Total effect		
	b	t	p	b	t	p
Handedness in solving the problem	— -	— -	— -	0.53 6	6.75 7	p < 0.01

The findings indicate that handedness had no direct effect on students' problem-solving (p<0.01, t=6.76, and b=0.54).

Conclusion

In the context of the relationship between handedness and hemispheric asymmetry, Broca stated that the ability to speak and the skill of the right hand in dominant right-handed people are associated with the superiority of the left hemisphere in the embryonic period, and in the few dominant left-handed people, the ability to speak is associated with the right hemisphere and handedness. Broca's law, stating that inhibition of speech is located in the hemisphere opposite the handedness, was accepted as law during the 20th century and was very suitable to justify the connection between left hemisphere damage and anesthesia in right-dominant people. However, some cases were found that Broca's law could not be justified, left-handed

people who suffered from damage to their left hemisphere were speechless, and these cases revealed that left-handedness is not necessarily a simple reversal of right-handedness (ibid). Despite the lack of information and sufficient data in this regard, some studies state a relationship between the handedness and some structural asymmetries of the brain, especially the increase or decrease of the asymmetry of the temporal planum and the left dominant. It is unclear whether the asymmetries in the motor cortex determine the handedness or whether the handedness causes asymmetry in the motor cortex. The handedness and very subtle asymmetries in the motor cortex seem to be associated with the structural and functional asymmetries involved in language processes, including the temporal planum, the primary auditory cortex, and the communication cortex of the areas around the Sylvian sulcus. The relationship between language dominance and handedness is not a linear relationship; in approximately 97% of right-handed people, the left hemisphere is specialized for speaking and understanding language, whereas only 3% of right-handed people have bilateral or right-hemisphere representations for language and speak and these connections, respectively, can be seen in 70% and 30% of left-handed people (Toga, 2021).

The findings from all related studies state that degrees of asymmetry of brain axes are found in all the mechanisms affecting handedness. It is clear that hemispheric asymmetry, lateralization of the tongue, and handedness have common and interdependent relationships, but in a complicated manner. Many elements like heredity, environmental events, neurochemical asymmetries, personal experiences, and diseases can affect this relationship. The relationship between handedness and hemispheric asymmetry is a question that has remained unanswered till now (Toga, 2021). Regarding the prevalence of left-hand dominance, there are different statistics that do not vary that much: 90-95% of people are right-dominant. Hence, left dominance or, more precisely, non-right superiority is seen in 5 to 10% of the society and, more preferably, in men. One must emphasize that people are on a spectrum in terms of handedness; on one side of which, there are completely right-handed people, and on the other side, there are completely left-handed people. The people between these two groups with less number are ambidextrous or mixed handers. It is interesting that there are behaviors in humans strongly lateralized, but their direction does not necessarily correspond to the direction of handwriting, like arm-folding, hand clasping, and leg crossing that always happen in the same way in the same person (Nowrouzian, 2007).

Approximately 6 to 17% of society people are left-handed, 3 to 17% are ambidextrous, and 66 to 89% are right-handed. Hence, handedness is a relative matter, so some are left-

dominant, some are ambidextrous, and the rest are right-dominant (Khodapanahi, 2003).

The study findings indicated that handedness did not have a direct effect on students' problem-solving. The consistent results of the study could be compared with those of Shimoda et al. (2008), Reio, Czarnolewski, & Eliot, Nowrouzian (2006), and Springer and Dasch (1998) in this regard. In explaining this, one could refer to the Geschwind-Behan-Galaburda (1982) theory, known as the GBG model.

One of the limitations of the study is that only the handedness is in line with this study, and lateralization of other organs is not considered. Another limitation of the study is the limited population in terms of age. It is expected that left-handed people and right-handed people have differences in terms of mental and cognitive functions; thus, it is suggested that the counselors of schools and specialized psychological centers of students must consider this issue in the academic guidance towards the related majors.

References

- Alipour, A., and Kalantarian, Sh. (2011). Investigating the relationship between handedness and the academic progress of middle school students. *Journal of School Psychology*, 1, 1, 7-26.
- Alipour, A., and Mardani Rad, M. (2011). Examining the rotation status in left-handed and right-handed people in order to provide suggestions on driving behavior. *Research Studies Quarterly*, 2, 1, 53-35.
- Annet, M.(2020). *Handedness and brain asymmetry: The right shift theory*. .hove: Psychology.
- Anders, S.M. & Hampson, E.(2005). Testing the prenatal androgen hypothesis: Measuring digit ratio, sexual orientation and spatial abilities in adult. *Horm and Behav*,47,92-8.
- Bishop, D.(1990). *Handedness and developmental disorders*.First Edition LEA publication.
- Brenneman, M.H., Scott Decker, S., Joel Meyers, J. , & Johnson, K.(2008). Does a continuous measure of handedness predict reading processes and reading-related skills across the lifespan? *Journal of Laterality*, 13 (6), 481- 503
- Bahrami, H. (2003). *Psychological tests*. Second edition, Tehran: Allameh Tabataba'i University Publications.
- Barnett, K. J., & Corballis, M. (2021). Ambidexterity and magical ideation laterality & Asymmetries of Body. *Brain and Cognition*, 7 (1), 75-84.
- Casey, M.B., Pezaris, E. & Nuttall, R.L. (1992). Spatial ability as a predictor of math achievement: The importance of sex and handedness patterns. *Neuropsychologia*, 30(1), 35 - 45.
- Castro-Schilo, L.,& Kee, D.W. (2010). Gender differences in the relationship between emotional intelligence and right hemisphere lateralization for facial processing. *Journal of Brain*, 73(1): 62-67.
- Cavill, s., & Brayden ,P.(2003).Development of handedness: comparison of questionnaire and performance-based measures of preference. *Brain and Cognition*,53,14
- Chapman, L. J., & Chapman, J.P.(1987).The measurement of handedness. *Brain Cogn*,6:174-183.
- Dadsetan, P. (1999). *Morbid and evolutionary psychology*, volume one. Tehran: SAMT.

- Dana , M.W., Bhadelia, R.A., Billings, R.L., Fulwiler, C., Heilman, K.M., Roob, K.M.J., & Gansler, D.A. (2020). Hemisphere connectivity and the visual-spatial divergent thinking component of creativity. *Brain and Cognition*, *70*, 267-272.
- Demyer, W.E . (1994) .The technique of the Neurologic Examination .(4th ed).McGraw :Hill .
- Denny, K., & O'Sullivan, V. (2020). The economic consequences of being left-handed have Some sinister results. *Journal of Human Resources*, *42*, 353-374.
- Gannon , P. J . (1998). Asymmetry of chimpanzee planum temporale: humanlike pattern of Wernicke's brain language area homolog. *Science*, *279*, 220– 222.
- Ghayas, S., & Adil, A. (2021). Effect of Handedness on Intelligence Level of Students. *Journal of the Indian Academy of Applied Psychology*, *33*(1):85- 91.
- Gilbert , A.N.,& Wysocki,C.J.(1992).Hand preference and age in the united states. *Neuropsychologia*, *30*, 601-608.
- Khosravinezhad , P. , & Teimourzadeh , S. (2010). Handedness and lateralization of the brain. *Broad Research in Artificial Intelligence and Neuroscience*, *2*, 1, 2067-3957.
- Kolb,B.,& Whishaw ,I.(2022).*Fundamental of human neuropsychology* .12th edition.The USA .New York Oxford University Press.
- Krommydas , G ., Gourgoulianis, K.I., Andreou , G., Kotrotsiou ,E.,Raftopoulos,V.,ParalikasT.H., & Molyvdas, P.A.(2004).Fetal sensitivity to testosterone, left-handedness ,and development of bronchial asthma: A new approach.*Med Hypotheses*, *62*,143- 5.
- Krommydas , G ., Gourgoulianis, K.I., Andreou , G., Kotrotsiou ,E.,Raftopoulos,V.,Paralikas, T.H., & Molyvdas, P.A.(2004).Fetal sensitivity to testosterone left-handedness and development of bronchial asthma: A new approach.*Med Hypotheses*, *62*,143- 5.
- Khaleghi Delavar, F., and Alipour, A. (2013). Lateralization, understanding humor, and happiness. *Social Cognition*, *3*, 2, 117-125.
- Khodapanahi, M.K. (2003). *Neuropsychology and psychophysiology*. Tehran: SAMT.
- Kayani, M. (2019). A comparative study of the number of lateral dominance functions of the brain in mentally retarded children with an intellectual age of 5-6 years in special education centers. Master's thesis, University of Welfare and Rehabilitation Sciences.
- McCrea, S. M. (2010).Intuition, insight, and the right hemisphere: Emergence of higher sociocognitive functions. *Psychology Research and Behavior Management*,*3*,1- 39.
- McManus, C. (2022). *Right hand, Left hand*. (10rd). England: Phoenix.
- McManus, C., & Drury, h. (2004). The handedness of Leonardo do Vinci. *A Brain and Cognition*, *55*. 268-292.
- Mihov, K. M., Denzler, M., & Forster, J. (2010). Hemispheric specialization and creative thinking: A meta-analytic review of lateralization of creativity. *Brain and Cognition* *72*, 442-448
- Mohr, M., Thut , G. , Landis ,T. & Peter bruggger .(2003). Hands, arms, and minds: Interactions between posture and Thought.*Journal of clinical and Experimental neuropsychology*,*25*, 1000-1010 .
- Myers, G. D. (2022). *Psychology* .(13th ed.). NewYork: Worth Publishers.
- Nowrouzian, M. (2006). Left hemisphere, right hemisphere, right hemisphere, and left hemisphere. Ph.D. thesis, Tehran University of Medical Sciences.
- Pinel , J.(2006). *Biopsychology*.Boston : Allyn and Bakon.
- Pithers, R.T. (2002). Cognitive learning style: A review of the field dependent-field independent approach. *Journal of Vocational Education and Training*, *54*, 117- 132.
- Raymond , M. , & Pontier , D.(2004) . Is there geographical variation in human handedness? *Laterality*, *9*,35-52.
- Reio , T.G., Czarnolewski , M. , & Eliot , J.(2004).Handedness and spatial ability: Differential patterns of relationships.*Laterality*, *9*, 339-58
- Richardson, J. A., McManus, C., & Drury, h. (2004). The handedness of Leonardo do Vinci. *A Brain and Cognition*, *55*. 268-292.
- Selagi, Z., and Alipour, A. (2012). Comparison of social intelligence and emotional intelligence of students according to their handedness. *Applied Psychology Quarterly*, *4*, 24, 119-103.
- Seif, A.A. (2021). *Modern educational psychology*. Fifth edition, Tehran: Doran.
- Shafiei, H., and Alipour, A. (2011). Handedness and lateralization of facial emotional processing in children who are new to cognitive science, *2*, 13, 23-34.
- Shapleske, S . L . (1999). The planum temporal: a systematic, quantitative review of its structural, functional and clinical significance. *Brain Res.Rev*, *29*, 26–49.
- Sherwood, C. (2003).Variability of Broca's area homologue in African great apes: implications for language evolution .*Anat. Rec. A Discov. Mol. Cell. Evol. Biol*, *271*, 276–285.
- Springer , D.(2020). *Left Brain, Right Brain*. 14th Edition. W. H. Freeman & Company publication, U. S. A.
- Toga, A. W. (2021). Mapping Brain Asymmetry. *Nature Reviews Neuroscience*, *4*, 37- 48.
- Zare, H., and Amirpour, B. (2012). Comparison of cognitive strategies of emotion regulation in right-handed and left-handed students, gender and month of birth. *Armaghane Danesh*, *3*, 17.