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Original Research Article

DO HAND PREFERENCE HAS A TIE-UP WITH COGNITIVE ABILITY? A CROSS-SECTIONAL STUDY AMONG THE ADOLESCENT SCHOOL STUDENTS

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ABSTRACT

Introduction: Handedness is perhaps the most overt reflection of lateralization of the central nervous system in humans. Humans show a strong and population-level bias toward using one hand rather than the other for manual activities, which is unusual among mammals. As handedness is biologically and genetically linked, so it has various effects on one's behaviour and abilities. Since intelligence has an impact on human behaviour, intelligence is considered an important aspect. Language is a system by communication. The meaning of anything is created by using symbols and our intelligence can be communicated to others by reading, speaking and writing. Researchers argue that right handers are more intelligent than the left handers and this is the reason behind changing the handedness of the children. This present study aims at finding the authencity of this opinion.

Aim: We assessed the cerebral dominance and association between handedness and intelligence among school students.

Method: Lateral preference inventory for handedness and Raven's Standard Progressive Matrix Test for intelligence.

Statistical method used: IBM statistics-20. The P-Values less than or equal to 0.05 ($\leq$0.05) were considered as statistically significant.

Result: Statistical significance results were observed between left and right handers in terms of gender, age and educational standards.

Conclusion: Left handed students were more intelligent than right handed students. Furthermore if more accessories are specially designed for left handers, they can achieve much more better.

KEY WORDS: Left handers, right handers, cerebral dominance, intelligence, language.

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INTRODUCTION

Human beings are considered unique from other species of creation taking into account the tremendous mental abilities they possess. In fact, this has helped human beings to discover the various areas of the world and experience progress in every aspect of scientific achievements. Inspite of all mental abilities, many differences exist among us which can be considered the individuality of a person and one such is the notion of handedness. When the cerebral cortex of the forebrain is viewed from

the top, it is divided into two mirror images namely left and right hemisphere. The body is basically bilaterally symmetrical, except some internal organs like the heart. The receptive control centres for one side of the body are in the opposite hemisphere of the brain. Often, one hemisphere is obviously dominant in various process and this is known as lateralization. In other words, when one side of the body is used more than the other in performing certain special task, where one hemisphere is dominant it can be called as lateralization. For instance a person happens to be right handed if the left hemisphere of the person is more dominant than the other. On the other hand, if a person uses the left hand more than the other, the right hemisphere is more dominant [1]. Bias against left-handed people is prejudice against people who are left-hand dominant. Approximately one-tenth of the world's population is left-handed [2].

The unfavourable connotations of the use of the left hand among cultures are varied. Across most of the cultures, as part of upholding cleanliness, the right hand was used for eating, handshake and for many other social interactions, whereas the left hand is used for maintaining personal hygiene. Social traditions have imparted these behaviour on its people community irrespective of their dominant hand, thereby giving evolution to the perspective of considering the left hand as unclean[3] .Many studies have been done learning the brain functioning of intelligent people. Intelligence have been classified into seven distinct factors called primary mental abilities - verbal, word fluency, spatial ability, comprehension, numerical ability, inductive reasoning ,perceptual speed, and memory [4].

Research has proved that people with great intelligence have the capacity to retrieve information quickly. Studies have also proved that the right hemisphere is more activated during perceptual tasks. Therefore, the right hemisphere in intelligent people would be more specialized [5]. A person's IQ is influenced by the length of time a person had passes in school. Indirectly the intelligence of a person is affected by education [6]. Mostly the handedness of a person is recognised at school. As teachers and parents feel left handedness is unacceptable in the society, they play a vital role in making the left handed students right handers. Psychologically the left handers are troubled often. They feel ashamed and inadequate[7].

For instance, greeting a person, or getting or giving something from a person with left hand is unacceptable or an act of disrespect in many countries. The individuals strength lies not in left cerebral hemisphere in making the left handers do things with the right hand and it is rather hard and even more stressful to the left hander. Added to this misery, most of the machineries ,technological gadgets, sewing machines and cars are designed for the right handers. When the left handers are forced to change as right handers, due to societal unacceptance, they result in slow reasoning, poor handwriting etc., In terms of their psychological, educational and social functioning, this creates a lot of difficulties in the left handers of our society.

Theoretical background:

Split brain theory: The gross result of research by Sperry can be recapitulated by his quote "Everything we have seen indicates that the surgery has left these people with two separating minds, that is two separate spheres of consciousness". This research has brought out some significant differences between the two hemispheres. Let us consider two patients who have damage to the brain on one hemisphere of the brain, when they are asked to copy a diagram, the overall outline of the diagram will be copied by the patient with left brain damage. On the other hand, the person would be able to give the correct details but not the overall outline [8].

Brain Dominance Theory:

The work of Sperry was drawn and developed further by Ned Hermann who is considered the father of brain dominance technology. People tend to develop a dominant mode of thinking preference according to the Brain dominance theory. For instance it would range from the analytical left brain approach to the matching and intuitive understanding of the right brain. These preferences which affects our cognitive capabilities have their roots in our genetic make up. For example, left- right hand preferences of a person can be identified in the womb itself.

Hermann also developed the four quadrant model of cognitive preference.

A: Left cerebral hemisphere – analytical.

B: Left limbic system – sequential.

C: Right limbic system – interpersonal.

D: Right cerebral hemisphere – imaginative.

Quadrant A: Analytical Thinking.

Key word: Logical, factual, critical, technical and quantitative.

Preferred activities: Collecting data, listening to informational lectures, reading textbooks.

Judging ideas based on facts, criteria and logical reasoning

Quadrant B: Sequential Thinking.

Key word: Conservative, structured, organised, detailed and planned.

Preferred activities: Following direction, repetitive detailed homework problems, time management and schedules.

Quadrant C: Interpersonal Thinking.

Key word: Kinaesthetic, emotional, spiritual, sensory, feeling.

Preferred activities: Listening to and sharing ideas, looking for personal meaning, sensory input and group study.

Quadrant D: Imaginative Thinking

Key word: Visual, holistic, intuitive, innovative, and conceptual.

Preferred activities: Looking at the big picture, taking initiative, simulations, visual aids.

Appreciating beauty of a problem, brain storming [9].

The left hemisphere controls the language function of most of right handers ie around 97 %. Language distribution can be found more even in left handers. That is, its concentration in the left hemisphere is 18%, 68% in the right hemisphere and the remaining in both hemispheres [10].

A trait that is closely associated with quantitative variation is handedness, reflecting cerebral dominance. Researchers have different opinion about if this variation is a correlate of human cognitive ability because it underlies the specific characteristics of language. This also seems that lesser degrees of lateralization are associated with verbal and non-verbal development delay. It also seems that lateralization is associated with significant variation in the rate at which meaning is acquired from words. This variation reflects a dimension that is specific to homo sapiens. The mechanism of transition from a precursor hominid is reflected in the genetics of lateralization. It should be noted that there are sex differences in both handedness. In average, girls are more right handed and they are also less likely to be left handed than boys. Girls acquire verbal ability faster than boys. Obviously, it is possible that the relevant gene is linked and are X-Y homologous locus is suggested [11] .

Aim: At times left handers are treated abusively and nicknamed. Researchers argue that right handers are more intelligent than the left handers and this is the reason behind changing the handedness of the children. This present study aims at finding the authencity of this opinion.

MATERIALS AND METHODS

A sample of 210 student volunteers were selected from various schools for the study. They were selected in such a way that the sample for our study consisted of equal number of right handed and left handed volunteers. Sample selection was based on Systematic random sampling method.

The lateral preference namely handedness was assessed by lateral preference inventory [12] .

Intelligence was assessed by Raven's Standard Progressive Matrices Test [13].

RSPMT comprises of 60 questions with 5 different levels (A,B,C,D,E) each with 12 questions asked in order of increasing complexity. Demographical sheets were given to obtain the required personal information and also confidentiality was ensured. The objectives and the nature of the present study were briefed. According to the instructions participants were asked to take RSPMT. Test was conducted in 105 separate setting with one left and right hander in each setting, and were asked to choose suitable option in all the sixty questions. During the performance of RSPMT the time taken to complete the test and marks scored by the students were noted and later analyzed with

reference to their handedness.

Inclusion criteria

1. Consenting individuals both male and female between 11- 17 years.

2. Consenting right handers matching to left handers were rolled in.

Exclusion criteria

1. Individuals having any gross deformity were excluded

2. Individuals who cannot give consent to participate in the study.

The parents of these volunteers were informed about the intended study, its procedures and consent was also obtained from the parents of each volunteer before inclusion in this protocol, which received the approval of the Institutional Human Ethics Committee.

Statistical Analysis: The statistical analysis and interpretations were performed by the statistical package namely IBM statistics-20. The P-Values less than or equal to 0.05 ($P \leq 0.05$) were considered as statistically significant.

RESULTS

Ravens test was carried out for significance of handedness over students from different quality of educational Institutions in India: Government, Matriculation and Central Board of School Education (CBSE).Among these institutions CBSE stands top in the educational standards compared to that offered in Matriculation schools, followed by the Government institutions. Two tailed statistical analysis test was carried out to analyse handedness under various factors namely school category, age and gender.

Statistical significance test was carried using the scores obtained by the left and right handed students to analyse handedness and the influence of different education institutions in Table 1.Analysis shows that under government school category, the scores secured in the various level did not show much significance between the left and right handers in all the 5 levels with the result being not significant (P>0.05). Under matriculation school category both the left and right handed students had secured more marks compared to that of government school. Statistical significance were observed in the higher difficulty levels of C (p=0.046) &D (p=0.018) though the levels A, B & E did not show significant difference between the left and right. The results of CBSE school category in table - 3 exhibits higher level of significance in all the categories in all the 5 levels when compared to government and matriculation schools with the levels B (p=0.004), D (p=0.046) and E (p=0.040) respectively being very significant and thereby resulting in a significant raw score value. When all the three school categories were considered it can be inferred that handedness shows statistical significance in the higher difficulty level. The quality of education system provided for CBSE students thereby exhibits the influence of education in the intelligence of left handed students.

The raw scores of the students were graded as per Ravens progressive test rules and significance test values using the graded RSPMT scores for the different school categories are tabulated in Table 2. From Table 2 it is inferred that, in terms of RSPMT grading also the intelligence level in CBSE students showed statistical significance (P<0.05)when compared to Matriculation and Government school students. Though the P values for government (P=0.340) and matriculation (P=0.078) did not turn up to be statistically significant, the values shows the improvement in the influence of school category in the intelligence of left handers with the progressive increase in level of significance from the government to the matriculation and to the CBSE category.

Table -3 shows the statistical analysis for the significance of handedness on the time of completion for the different school categories. There is a progressive increase in the level of significance from the Government school category towards CBSE with the significance value appearing to be P=0.166 for Government, P=0.064 for Matriculation & P=0.004 for Government schools, wherein the handedness comes out to be statistically significant in terms of time of completion for level in CBSE school category. This clearly shows a prominent dependency of handedness on time of completion in case of CBSE category as against the matriculation and government school which shows the

impact of education standard having an influencing the intelligence.

Table 4 provides the significance test values for the analysis of handedness with respect to age. Here we have mapped the school level with age as follows: Age group 11-13: Students from Middle school, 14-15: Students from High school, 16 -17: Students from Higher Secondary School. Statistical significance is exhibited between left and right handers in all the age groups. We could understand that as age increases results are becoming extremely significant which tell us that age plays a vital role in bring out the characteristic growth of significance in handedness.

Table 5 shows the gender based analysis of the scores obtained by the left and right handed male and female students. The mean value of scores obtained by male students are higher than that of female students with the left handed male students showing the highest mean score of 43.71.

Table 1: Comparison of Raw score and its components with handedness for students under different school categories.

School Category	Raw Score	LEFT		RIGHT		df	't' value	Significance
		MEAN	SD	MEAN	SD			
Government School	A	9.91	2.02	9.95	1.64	42	0.08	0.937
	B	9.59	2.41	8.09	2.66	42	1.916	0.062
	C	7.23	2.19	7.27	2.36	42	0.064	0.949
	D	6.73	2.09	5.86	2.2	42	1.303	0.199
	E	2.82	1.8	2.09	1.83	42	1.298	0.201
	Total Score	36.27	8.6	33.27	9.22	42	1.09	0.282
Matriculation School	A	10.87	0.88	10.76	1.13	72	0.455	0.65
	B	10.19	2.03	9.62	2.07	72	1.172	0.245
	C	8.54	1.99	7.57	2.07	72	2.029	**0.046**
	D	8.73	2.29	7.41	2.34	72	2.428	**0.018**
	E	5.68	2.7	4.78	3.26	72	1.263	0.211
	Total Score	44	8.63	40.19	8.71	72	1.865	0.066
CBSE School	A	10.95	0.81	10.65	0.73	90	1.88	0.064
	B	10.89	1.46	9.91	1.64	90	2.98	**0.004**
	C	8.85	1.98	8.22	1.79	90	1.58	0.116
	D	9.02	2.35	8.02	2.35	90	2.02	**0.046**
	E	6.04	3.45	4.54	3.39	90	2.08	**0.04**
	Total Score	45.76	8.61	41.35	8.18	90	2.49	**0.015**

(df – degree of freedom; SD – standard deviation)

Table 2: Comparison of Intelligence with handedness in terms of RSPMT grading with respect to various school categories.

School Category	Handedness	N	Mean	SD	df	't'	Significance
CBSE	Left	46	16.17	7.08	90	2.28	**0.024**
	Right	46	13.02	5.93			
Matriculation	Left	37	14.92	6.56	72	1.791	0.078
	Right	37	12.27	5.98			
Government	Left	22	9.64	4.95	42	0.966	0.34
	Right	22	8.23	4.49			

Table 3: Comparison of Intelligence with handedness in terms of Time of Completion with respect to various school categories.

School Category	Handedness	N	Mean	SD	df	't'	Significance
CBSE	Left	46	25.59	7.25	90	2.96	**0.004**
	Right	46	30.11	7.24			
Matriculation	Left	37	27.43	6.76	72	1.884	0.064
	Right	37	30.62	7.56			
Government	Left	22	35.09	6.84	42	1.41	0.166
	Right	22	37.77	5.4			

Table 4: Comparison of Intelligence with handedness in terms of RSPMT grading with respect to age.

AGE	Handedness	n	Mean	SD	df	't'	Significance
(11-13) Middle School	Left	59	9.34	3.75	116	2.75	**0.0069**
	Right	59	7.58	3.13			
(14-15) High School	Left	28	18.61	3.32	54	3.245	**0.002**
	Right	28	15.57	3.55			
(16-17) Higher Secondary School	Left	18	24.22	3.41	34	3.673	**0.0008**
	Right	18	19.5	4.06			

Table 5: Comparison of Intelligence with handedness and gender.

Handedness	Gender	N	Raw score		RSPMT score	
			Mean value	SD	Mean value	SD
Left	Male	66	43.71	8.79	14.7	6.72
	Female	39	42.21	10.16	13.8	7.32
Right	Male	66	39.71	8.71	11.97	5.76
	Female	39	38.46	9.77	11.39	6.3

DISCUSSION

In the present study we have found that, in general, left handers were more intelligent than right handers; males being more intelligent than females. CBSE school category exhibiting high levels of significance compared to matriculation and government schools thus establishing the fact that education system also plays an important role in intelligence. In terms of age, significance in handedness increases with age.

A researcher had found that left handers contributed to higher score in Raven's i.e $P<0.01$ and the time taken to accomplish the task by left handers was less when compared to right handers $P<0.01$[14] . A significant level with $P<0.05$ on the scores on intelligence level and time taken to complete the task similar to the previous author $P<0.01$ was shown by another researcher[15] . Level of intelligence based on education level showed mean intelligent score of 114.35 for higher education level and 101.80 for low education level with standard deviation of 7.59 and 21.21 respectively[16] .The present study results were strengthened by the results shown by the previous works.

Interestingly there are some parts of the world where society has a sense of considering it as bad luck to meet a left-handed person when they start for a work or journey or for any good sake[17]. Also literature records that few other places have classified actions performed with left hand as rude behaviour. Especially in circumstances where one has to use gestures to say something or has to provide directions, these people will be cautious to keep their left hand behind and they physically strain their right hand to accomplish it [18].

Most communities belonging to the Asian sub-continent were reported to have enforcing right handedness to their children owing to the cultural perceptions of considering being left handed as bad luck. In India and Indonesia, it is considered rude to eat with the left hand[19].

As per a survey report conducted by Taiwan in 2007, their community exhibited that among the left handed students 59.3% were forced to change their inborn left handed behaviour. Their study took into account the economic status of families and have reported that students from poor educational background are most likely to be forced to convert. Even among children whose parents had higher levels of education, the conversion rate was 45.7% [20]. Amongst the naturally left-handed Japanese senior high school students, only 0.7% and 1.7% of individuals used their left hand for writing and eating respectively. Even though young Japanese are more likely to convert to using chopsticks right-handed than forks or spoons (29.3% to 4.6%) the proportion of females subjected to forced conversion is significantly higher compared to males (95.1% to 81.0%) [21].

Western countries also attempt to convert left-handed children on the following grounds: cultural, social and religious. Vital role is played by schools in forcing the students to get

practised with their right hands, sometimes even against willingness of parents. Incidents of students being physically punished for writing with their left hands were also reported [22].

Review of related studies: Examining patients with physical defect in one part of the brain, many theories of left-right hand specialization have been developed. One such investigation was Paul Broca's study. He nicknamed a person as Tan who had a large cyst in the left hemisphere of his broca's area. Tan could not say anything else other than his nickname "Tan". This study indicated that the left side of the brain had some language function. Moreover, when eight patients who had language problems were examined, they all had some damage in the left hemisphere. From there on, there existed research on the processing of language. Certain areas of the brain have been identified, which plays a part in language.

Motor speech area of Broca: Plays a part in the grammatical processing. It is located in the pars triangularis –area 45 and pars opercularis-area 44 in the inferior frontal gyrus of frontal lobe of left dominant hemisphere.

Sensory speech area of Wernicke: Plays a part in syntactical processing and is concerned with the interpretation of language through visual and auditory output. It is located in the posterior part of the superior temporal gyrus of temporal lobe in the left dominant hemisphere and angular –area 39 and supramarginal –area 40 gyri of inferior parietal lobule.

Angular gyri (area 39): Involved in the recognition of visual symbols.

Supra-marginal gyri (area 40): Involved in language processing [10].

Since intelligence has an impact on human behaviour, intelligence is considered an important aspect. Language is a system by communication. The meaning of anything is created by using symbols and our intelligence can be communicated to others by reading, speaking and writing. While operating the perisylvian region of the right hemisphere, it is important to the neurosurgeon to identify patients with atypical language localization[23].

Researchers are still unable to find out if it is genetic or not, to acquire the right or left hand preference. There are a number of theories explaining the preference of using either left hand or right hand in the activities of the daily life.

The Behavioural theory shows the preference of using a certain hand under pressure i.e using right hand instead of left hand under the compulsion and pressure of parents and teachers [24].

The Genetic theory has two dominant genes in which the first indicates the use of right hand while the second determines the use of left one. However, others deny the presence of using either right hand or left hand. It is incurred that it is used in random [25].

The Anatomical theory mentions that left handedness attributes to the early and rapid growth of the left hemisphere of the brain. Here, the planum temporale would be bigger in the left hemisphere than the right hemisphere [26].

The Hormonal theory states that the male hormone plays a vital role in determining brain laterality. This theory aims at describing the relationship between the males and left handers. It is observed that males tend to use more left hand than the females. Moreover, it is inferred that the function of the right part of the body including spatial and visual skills is more superior in the males than the females. This makes the males excel in fields like engineering, music and other jobs requiring technical skills, whereas the females are superior to males in the skill of left hand which includes lingual skills and manual skills. This theory brings forth the idea that the male hormone delays the growth of some parts of the left cerebral hemisphere [27].

The relationship between using one hand and the spatial ability was examined and it was found that there was no significant association between the use of hand and gender [26].All correlations were not statistically significant at 0.05 level in the study made by a researcher, who examined the factors related to hemisphericity, gender and handedness [28].

The importance of the study: Studies and researches on brain can change our perspective about brain growth and its function. Educational systems used are usually concerned with the

functions of the left hemisphere at the expanse of the right one. The functions and skills of this hemisphere is ignored often as there is human discrimination for the left hemisphere and right handedness. The present study is focused on the importance of bringing out a change in the nature of the curriculum prescribed in the board of school education so that it paves way to develop skills of both hemispheres because handedness represents a link preference existing in both the hemispheres.

The quality of learning is enhanced among educators and teachers by increasing the knowledge of the two brain hemispheres working mechanism. This can be implemented effectively by renewing the curriculum planning and allocating certain activities to the left handed students. It is recognised important to identify the differences between females and males regarding brain hemisphericity and handedness. This would certainly contribute to the research related to the causes of these differences as well as promote using suitable educational and psychological programs for both genders. The relation between the motor growth and other types of growth manifestation is obviously recognized to be important and integrative. Since the results of various studies related to the hemisphericity, gender differences and relation between the hemisphericity and handedness are not definite, further research is recommended to reach better or definite results.

CONCLUSION

Since majority of the people community are having right handed practice, it is quite apparent to see almost all the physical aids and implements, in schools and institutions are designed to facilitate right handed actions. These manifest either as poor academic performance or physical ailments to the left handed students. Quite often we could see classrooms and lecture halls with the desks designed such that the writing surface is attached to the chair instead of being separate from it . In this design, the desk is attached on the right side, offering an armrest for right-handed people to use while writing. In some of these desks, the writing surface does not extend fully to the left, and as such a left handed user has to sit obliquely by turning their body and write their documents which could cause adverse effects to health and could develop problems related to back, neck and shoulder. At times in circumstances like examinations, this could also lead to accusing the students of copying or malpractice as from the invigilators point of view and thereby causing discomfort to the candidate.

To avoid these issues, provisions could be provided with left-handed desks so as to facilitate the comfort of left-handed candidates. Yet many common articles are designed for efficient use by right-handed people, and may be inconvenient, painful, or even dangerous for left-handed people to use. These include accessories like school desks, kitchen wares, to several industrial machinery which are difficult to handle by left handed persons, unless they are designed for the convenience of their left handedness. As the whole community is predominantly right-handed, almost all the products that we use in our routine lifestyle are mass produced for the ease of use with the right hand.

This demands that the accessories for the left handed persons inclusive of various fields like musical, gaming etc., must be specially ordered, which are usually found to be more expensive than that of the right-handed counterparts. Clarifying the association between handedness and functional brain specializations related to intelligence and learning further about the developmental and neurobiological procedures that forms the basis for these relationships, may improve us better in understanding a broad extent of seemingly unassociated issues such as human variation, developmental neurobiology of the brain, origins of human language, stuttering, dyslexia, and comparative researches on the brain.

Conflicts of Interests: **None**

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