A Study to Analyse the Relationship Between Visuospatial Ability and Hand Function in Normal Individuals

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KEYWORDS
Visuospatial ability, Hand function, Mirror drawing task

ABSTRACT
Introduction: Conditions like Stroke and Cerebral palsy patients have disturbance of both hand function and visuospatial ability. The parietal cortex is involved in visual control of hand movement. In bilateral posterior parietal lesions, subjects may have easy in object recognition but cannot point to it.
Objectives: This study intends to analyse the relationship between visuospatial ability and hand function in normal individuals based on the above background. The aim of this study is to analyse the relationship between visuospatial ability and hand function in young individuals.
Methods: 100 subjects were participated with the age of 20-30 years included. They performed mirror drawing task with both hands and answered ABILHAND questionnaire.
Results: The data has been analyzed by the SPSS 22nd version software. The Nonparametric correlation test [Kendall's tau_b] was used for analysing the derived data for time taken and errors committed in completing the visuospatial tasks and hand function. The right side error committed for completing visuospatial task decreases the right side hand function will increases it is statistically significant. The left side error committed for completing visuospatial task increased the left side hand function decreased but it is not statistically significant
Conclusions: It has been concluded that visuospatial ability has a more significant impact over hand function. As visuospatial ability components should also be considered in rehab protocol for various motor and function impairment of hand.

1. Introduction

Visuospatial Perception:

Visuospatial ability is one of the components of cognitive functioning and it refers to our ability to interpret visual information about where objects are in space Visuospatial perception underlies our ability to move around in an environment appropriately. The right and left parietal lobe are responsible for visuospatial skills Some studies suggest that the parietal lobes are extensively involved in spatial perception and visuospatial function [Ancelin ML et al., 2006]. The cognitive process of external representation from 2D to 3D is a key component of visuospatial reasoning [Schmahmann JD et al., 1998; Uchinokura S, 2022]. Mirror drawing tasks will help to assess visuospatial ability in terms of error committed and time taken [Bhushan B. et al 2000].

In bilateral posterior parietal lesions, subjects may have easy in object recognition but difficult to point them. In bilateral inferior occipitotemporal lesions, subjects will perform complex tests but fail to recognize familiar objects [Jeannerod M et al.,1994; Bai S et al., 2021]. Vision plays an important source of information for our ability to perceive our movements and detect the relative orientation of the body parts and orientation of the body in space.

Hand Function and Motor Skills:

The human hand is commonly known to achieve its predominance over that of other animals, by possessing an opposable thumb. The premotor area controls fine motor function of hand. The cerebellum receives their signals almost exclusively from the cerebral Cortex, especially from premotor area of the frontal and other sensory association area of parietal cortex. The frontoparietal

has some control of visuospatial ability and motor function in humans. The parietal occipital lesion shows deficits in reaching or grasping, imitating gestures and drawings or constructive block designs. The parietal cortex is involved in visual control of hand movement, the clinical symptoms manifested by lesion of the parietooccipital lesions.

2. Objectives

The right hemisphere excels in visuospatial ability such as with blocks and drawing maps and in musical sense, artistic sense and other higher functions of hand. The Left hemisphere excels in mathematical ability, symbolic thinking and sequential logic. Right side brain damage may result in deficits in prehension activities of ipsilateral hand [Farnè A et al., 2003]. The above background intends to find a relationship between visuospatial ability and hand function in normal individuals. This study intends to analyse the relationship between visuospatial ability and hand function in normal individuals based on the above background.

3. Methods

This observational study was conducted in Sri Ramachandra Medical Center and Hospital. A sample of 100 young individuals with ages between 20-30 years were included in this study. Any neurological insults, musculoskeletal dysfunction in upper limbs, psychological disability and present systemic disorder were excluded. Informed consent obtained

Procedure:

The subjects are first administered with mirror drawing tasks used for assessing visuospatial ability. This test involved tracing a star by looking at its reflection in the mirror. Here the subject traced the star without letting the stylus touch the sides of the star, and every time the stylus touches the sides of the star, the error counter made a clicking sound indicating an error and records the number of errors. The entire task is timed with a stopwatch. The subject first uses their right hand; after completing one trial with right hand the subject is asked to complete one trial with left hand. The time taken to complete the task and the number of errors made during the task are recorded which provide a measure of visuospatial ability.

Then subjects are made to assessed with an ABLIHAND questionnaire. Subjects are to estimate their perception on a response scale as either impossible or easy or difficult in performing each activity when the activities are done without other technical help.

The instructions are given to the patient only at the beginning of the test. The subsequent activities are neither preceded nor followed by any instruction. The examiner can repeat the instruction whenever the subjects show some hesitation in answering.

4. Results

The data has been analyzed by the SPSS 22nd version software. The Nonparametric correlation test [Kendall's tau_b] was used for analysing the derived data for time taken &errors committed in completing the visuospatial tasks and hand function.

Table 1- shows the values of mean and standard deviation for time, error and right side hand functions

Table 2 shows the nonparametric correlation between right side time & hand function and right side error & hand functions and their significance

As the right side time taken for completing visuospatial task increased the right side hand function also increased. But it is statistically not significant "P value"-.268.

As the right side error committed for completing visuospatial task decreases the right side hand function will increases it is statistically significant "P value" - .000

Table 3 shows the values of mean and standard deviation for time, error and left side hand functions

Table 4 shows the nonparametric correlation between left side time &hand functions and left side error & hand functions and their significance

As the left side time taken for completing visuospatial task increased the left side hand function decreased but it is statistically not significant “P value” - .896.

As the left side error for completing visuospatial task increased the left side hand function decreased but it is not statistically significant “P value” - .886.

5. Discussion

In this study Visuospatial ability was assessed in terms of errors committed and the time taken to complete the mirror drawing. Hand function is assessed by ABILHAND questionnaire helps fine and gross motor activities [Vandervelde L et al., 2010]. Visuospatial ability improved, the hand function also improved in right hand [the errors and hand function were directly significant when compared, while the time and hand function were not directly significant]. In the left hand visuospatial ability reduced and the hand functions also reduced [directly not significant]. The visuospatial ability and hand function deficits [like reaching, grasping, and drawing and construction blocks] were seen in the patients with parietal occipital lesion.

Some Studies suggested that the functional properties of parietal neurons are specifically related to hand movements. The parietal neurons receive both visual and motor signals for hand control and they play a crucial role in visual guidance of skilled movement. Cognitive functioning usually refers to different mental abilities, including thinking, learning, language, reasoning, attention and concentration, and visuospatial functioning [Kumar M et al., 2022]. In the bilateral posterior parietal lesions, deficits in grasping and in ability to adjust the hand orientation and in dissociated visuospatial ability were seen [Sunderland A et al., 1999].

Some corticocortical connections seen in between the parietal cortex and frontal cortex control the hand function. The rostral parts of the posterior bank of intra parietal sulcus in anterior intra parietal area are connected to premotor area. This region is responsible for visual guided hand actions [Heilman MK, 2010]. The posterior bilateral parietal regions will activate the movement of eye, hand and spatial organization. The motor signals of parietal regions receive input from premotor cortex (area 6), and it has reciprocal connections between the post arcuate cortex and bank of intraparietal sulcus. The right hand shows greater visuospatial ability and hand function compared to left hand. The subjects complete faster in the right hand than left hand with less errors. The left-hand dominant individuals presumed to have more bilateral representation of language and would do less visuospatial ability than right hand dominant individuals.

The right hemisphere was better able to detect mirror reversed and perform fine spatial discrimination, so the right hemisphere is better than left hemisphere in the visuospatial processing. The ipsilateral hand function affected after the right brain damage evidence for this is less clear.

While treating stroke and cerebral palsy patients, rehab protocol must be designed to improve visuospatial ability which will have impact on hand function. So, it is necessary to incorporate specific protocols for hand function which will improve visuospatial ability functions especially for parietal lobe lesion patients. Limitations of this study are Only young adults (20 -30 yrs) and right-handed dominant subjects were included. Different age groups can be analyzed and Left-handed dominant individuals can be included in further scope of this study.

6. Conclusion

It can be concluded that Visuospatial ability has more significant impact over hand function. Parietal region is responsible for visuospatial ability and hand function. Visuospatial ability components should also be considered in various motor/ hand function impairment in stroke patients.

References:

[1] Schmahmann JD, Sherman JC. The cerebellar cognitive affective syndrome. Brain: a J of Neurol. 1998 Apr 1;121(4):561-79.

[2] Uchinokura S, Koba K. Examination of children's visuospatial thinking skills in domain-general learning and interpretation of scientific diagrams. In Frontiers in Education 2022 Jul 22 (Vol. 7, p. 892362). Frontiers Media SA.

[3] Bhushan B, Dwivedi CB, Mishra R, Mandal MK. Performance on a mirror-drawing task by non-right-handers. The J of General Psychology. 2000 Jul 1;127(3):271-7.

[4] Jeannerod M, Decety J, Michel F. Impairment of grasping movements following a bilateral posterior parietal lesion. Neuropsychologia. 1994 Apr 1;32(4):369-80.

[5] Bai S, Liu W, Guan Y. The visuospatial and sensorimotor functions of posterior parietal cortex in drawing tasks: a review. Frontiers in aging neuroscience. 2021 Oct 14; 13:717002.

[6] Farnè A, Roy AC, Paulignan Y, Rode G, Rossetti Y, Boisson D, Jeannerod M. Visuo-motor control of the ipsilateral hand: evidence from right brain-damaged patients. Neuropsychologia. 2003 Jan 1;41(6):739-57.

[7] Vandervelde L, Van den Bergh PY, Penta M, Thonnard JL. Validation of the ABILHAND questionnaire to measure manual ability in children and adults with neuromuscular disorders. J Neurology, Neurosurgery & Psychiatry. 2010 May 1;81(5):506-12.

[8] Kumar M, Srivastava S, Muhammad TJ. Relationship between physical activity and cognitive functioning among older Indian adults. Scientific reports. 2022 Feb 17;12(1):2725.

[9] Sunderland A, Bowers MP, Sluman SM, Wilcock DJ, Ardron ME. Impaired dexterity of the ipsilateral hand after stroke and the relationship to cognitive deficit. Stroke. 1999 May;30(5):949-55.

[10] Heilman MK, Valenstein E. Clinical neuropsychology. Oxford University Press; 2010 Apr 10. Pg 150

Tables

Table 1 Shows the values of mean and standard deviation for time, error and right side hand function

	Mean	S.D.
Rt.time	34.1137	18.64546
Rt.error	19.46	17.677
Rt.hand function	43.55	4.031

S.D.= Standard deviation, Rt.time= Right side time, Rt.error= Right side error committed, Rt.hand function= Right side hand function

Table 2 Shows the nonparametric correlation between right side time & hand function and right side error & hand function and their significance

	Correlation coefficient	Significance
Rt.time and rt .hand function	.083	.268
Rt.erorr and rt. Hand function	-.633	.000

Rt.time= Right side time, Rt.error= Right side error committed, Rt.hand function= Right side hand function

Table 3 Shows the values of mean and standard deviation for time, error and left side hand functions

	Mean	Standard deviation
Lt.time	47.9695	30.88911
Lt.error	56.73	35.716
Lt.hand function	29.43	7.331

S.D.= Standard deviation, Lt.time= Left side time, Lt.error= Left side error committed, Lt.hand function= Left side hand function

Table 4 Shows the nonparametric correlation between left side time & hand functions and left side error & hand function and their significance

	correlation coefficient	Significnace
Lt.time and lt hand function	-.009	.896
Lt.error and lt hand function	-.010	.886

Lt.time= Left side time, Lt.error= Left side error committed, Lt.hand function= Left side hand function

Figures:

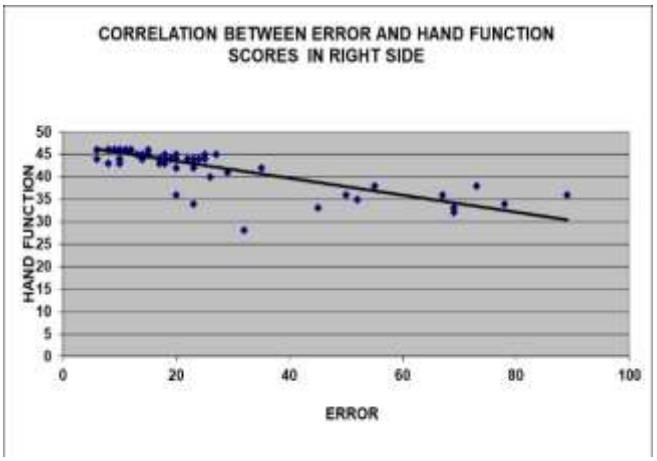

Figure S1: Correlation Between Error and Hand Function Scores in Right Side

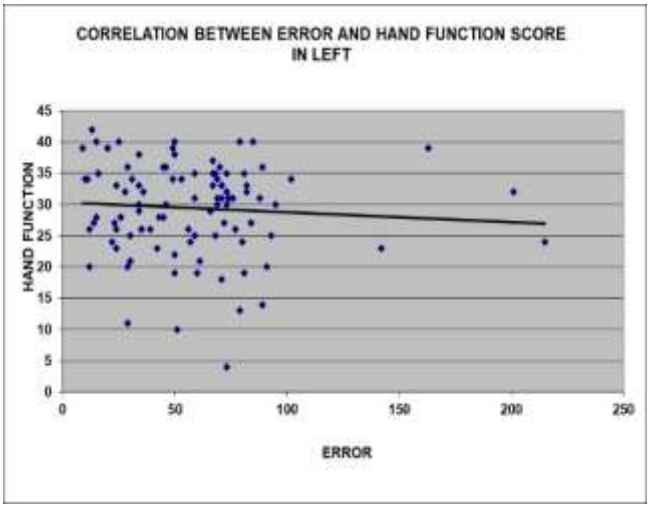

Figure S2: Correlation Between Error and Hand Function Scores in Left Side

Figure S3: Mirror Drawing Task