Current Journal of Applied Science and Technology

39(26): 70-76, 2020; Article no.CJAST.60723
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Study on Contribution of Genetic and Environment to Perceptual Cognitive Skills of Twins

Annu[1*] and Bimla Dhanda[2]

[1]Human Development and Family Studies Department, I.C. College of Home Science, Chaudhary Charan Singh, Haryana Agricultural University, Hisar-125004, Haryana, India.
[2]I.C. College of Home Science, Chaudhary Charan Singh, Haryana Agricultural University, Hisar-125004, Haryana, India.

Authors' contributions

This work was carried out in collaboration between both authors. Author Annu designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BD critically reviewed the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i2630906
Editor(s):
(1) Dr. Ritu Singh, G.B. Pant University of Agriculture and Technology, India.
Reviewers:
(1) Srinivas Sethi, Indira Gandhi Institute of Technology, India.
(2) Pramod Kattel, B. P. Smriti Hospital, Nepal.
(3) Wafik Said Bahnasy, Tanta University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60723

Original Research Article

Received 24 June 2020
Accepted 28 August 2020
Published 03 September 2020

ABSTRACT

The contribution of genetic was ranging from 50-65% in the variations of perceptual cognitive skills of twins. The current twin study design elucidated the contribution of genetic and environment to a wide range of perceptual cognitive skills. To conduct twin study, 100 pairs of twins from two districts namely; Bhiwani (N = 90) and Hisar (N = 110) of Haryana State were taken. Genetic and environmental influences were assessed in twin study design. The perceptual cognitive skills of twins were measured using the Wechsler Intelligence Scale for Children- Revised (WISC-R). Heritability estimate was used to examine the genes contributed to shape the cognitive skills of twins. The result of heritability estimates revealed that the heritability estimates of perceptual cognitive skills namely picture completion, picture arrangement, block design and object assembly in Bhiwani district were 63%, 57%, 61% and 60% and in Hisar district were 54%, 52%, 58% and 56% respectively. The findings clearly elucidated that the perceptual cognitive skills were more influenced by genetic background than the environmental factors. The monozygotic twins were more correlated in their general cognitive abilities than the dizygotic twins.

**Corresponding author: E-mail: annupanghal1997@gmail.com;*

Keywords: Genetic; heredity; environment; monozygotic twins; dizygotic twins.

1. INTRODUCTION

Researchers of psychology classically differentiate individual differences in cognitive abilities. Genetic influences on cognitive ability were maximized when people are free to select their own learning experiences. The children are born with blueprints of social, educational and economic opportunities etc. which are reflected into their genetic potential [1]. According to monozygotic and dizygotic twin studies cognitive levels and cognitive abilities are influenced by individual's genetic background. The correlation of cognitive abilities between twins was decline with age [2].

Heritability may be defined as the proportion of variation that arises from genetic influences. The role of heritability was also substantial to detect this genetic influence on cognition [3]. The heritability studies with twin design contributed the most optimal estimation of genetic and environmental effects [4]. The heritability estimates from identical and fraternal twins are used to estimate the extent to which early genetic influences on cognition were amplified over time [5].

The heritability of educational attainment increases from age group 11-16 years. The genetic influences on inter individual differences increases gradually found to account for 48-60 per cent variance in the age group 11-16 years [6]. Moreover the heritability of some cognitive abilities increases over childhood [7]. The individual differences in cognitive abilities due to genetic factors were found by the studies of genome-wide association with very large samples [8]. The variations in cognitive abilities accounted for genetic background were more stable than environmental factors [9]. Further, there was evidence that genetic effects on patterns of brain change over time and the magnitude of relative genetic versus environmental influences may increase over the course of [10].

The degree of genetic variation increases gradually from early childhood to adulthood but environmental variation decreases. The family environment, high socio-economic status with high income, birth order of child and parenting techniques could be beneficial for cognitive development of children [11]. Lyons, et al. [12] Revealed that heritability and general cognitive abilities increased slowly throughout the lifetime. The reason was attributed to a regular increase in active genotype-environment covariance. They also concluded that the heritability and general cognitive ability mainly increased linearly from childhood to young adulthood.

Mitchell, et al. [13] provided compelling evidence across four longitudinal studies that changed in everyday cognitive activity with variation in multiple aspects of cognitive function. The change in activity was associated with relative change in cognitive performance.DeFeries, et al. [14] Showed that genetic correlations between diverse tests of verbal and nonverbal cognitive abilities are greater than 0.50. Moreover, the findings supported that most of the genes influenced all cognitive abilities. Elliot, et al. [5] observed through longitudinal studies on cognition that genetic and environmental mechanism in the longitudinal stability of cognition, and developmental trends therein. However, the patterns of stability of genetic and environmental influences on cognition over the lifespan largely remain poorly understood. The current twin study was formulated with the aim to find out genetic and environmental contribution to perceptual cognitive skills.

2. MATERIALS AND METHODS

2.1 Study Design

The present twin study model was conducted in the rural areas of purposively selected villages from two districts, namely, Bhiwani (N=90) and Hisar (N=110) of State Haryana. The purpose of selection of Haryana state and district was availability of maximum numbers of twins in the required age group of 6-8 years and proximity with Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The twin study was conducted in the 2018-2019 with one year duration. This study was done with association of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.

2.2 Data Collection

The assessment, interview, observation and questionnaire methods were used to take out the information from twins.

2.3 Tool

The cognitive skills of twins were examined by The Wechsler Intelligence Scale for Children-Revised (WISC-R) [15]. The perceptual cognitive

skills included picture completion, picture arrangement, block design and object assembly.

2.4 Statistical Analysis

The statistical analysis performed in software SPSS (Statistical Package for the Social Sciences). Mean, Standard Deviation, z-test, correlation coefficient and heritable estimate were used to meet the objectives of the study. Heritability estimates (h^2) were calculated by the following formula given by [16], h^2= 2(RMz- RDz) Where, h^2 is the heritability estimate, RMz is the correlation coefficient for monozygotic twin pairs and RDz is the correlation coefficient for dizygotic twins. Correlation coefficient was used to find the correlation between the perceptual cognitive skills of twins.

3. RESULTS

3.1 Perceptual Cognitive Dimensions of Twins in Two Districts

As presented in Table 1 there were highly significant differences in mean values for object assembly (Z=2.89**) cognitive dimensions of twins of Bhiwani and Hisar districts. The significant (0.05%) differences were found between twins of Bhiwani and Hisar districts on dimensions of cognitive picture arrangement (Z=2.03*) and picture completion (Z=2.02*), but no significant differences were found for remaining dimensions of cognition block design (Z=1.36) over the districts. Twins at Bhiwani district performed better for all the same mentioned dimensions as compared to their counter parts from Hisar district.

3.2 Heritability Estimates for Perceptual Cognitive Skills in Both Districts

The heritability estimates for perceptual cognitive skills are Picture completion (63%), Picture arrangement (57%), Block design (61%) and Object assembly (60%) in Bhiwani district. In Table 2, the data clearly indicated that the remaining 37 per cent variance in picture completion cognitive skills were due to environmental factors. Further the data portraited that 43 per cent, 39 per cent and 40 per cent variance in picture arrangement, block design and object assembly respectively were due to environmental circumstances. In Hisar district, the heritability estimates for picture completion, picture arrangement, block design and object assembly were 54 per cent, 52 per cent, 58 per cent and 56 per cent respectively. This clearly indicated that remaining 46 per cent variance in picture completion was due to environmental factors and 48 per cent, 42 per cent and 44 per cent in picture arrangement, block design and object assembly respectively contributed to environmental situations. The heritability estimates clearly revealed that more genetic influence on picture completion perceptual cognitive skills followed by block design, object assembly and picture arrangement perceptual cognitive skills in Bhiwani district. In Hisar district, the heritability estimates accounted for block design was highest (58%) followed by object assembly (56%), picture completion (54%) and heritability was lowest for picture arrangement (52%). The genetic influence was more on block design followed by object assembly, picture completion and picture arrangement perceptual cognitive skills in Hisar district. The Table 2 portrait regarding the heritability estimates for perceptual cognitive skills of twins in both districts namely: Bhiwani and Hisar.

3.3 Correlation Coefficient among Monozygotic Twins and Dizygotic Twins for Perceptual Cognitive Skills in Both Districts

The Table 3 provided the information regarding the correlation coefficient among monozygotic and dizygotic twins for perceptual cognitive skills in Bhiwani and Hisar district. The data in Table 3 portrait that the correlation coefficient among monozygotic twins for perceptual cognitive skills namely: Picture completion, Picture arrangement, Block design and Object assembly was r=0.81, r=0.71, r=062. and r=0.78 respectively in Bhiwani district. Among dizygotic twins, the correlation coefficient in Bhiwani district are picture completion (r=0.49), picture arrangement (r=0.43), block design (r=0.32) and object assembly (r=0.48). Further the correlation coefficient among monozygotic twins in Hisar district for perceptual cognitive skills was; picture completion (r=0.76), picture arrangement (r=0.72), block design (r=0.72) and object assembly (r=0.75). Among dizygotic twins, the correlation coefficient was for picture completion (r=0.49), picture arrangement (r=0.45), block design (r=0.43) and object assembly (r=0.47) in Hisar district. The data clearly indicated that monozygotic twins were more correlated with each other in all perceptual cognitive skills as compared to dizygotic twins in both Bhiwani and Hisar district.

Table 1. Perceptual cognitive dimensions of twins in two districts (N=200)

Cognitive dimensions	Bhiwani (n=90) Mean±SD	Hisar (n=110) Mean±SD	Z Value
Picture Completion	4.35±1.95	3.85±2.24	2.02*
Picture Arrangement	2.64±1.34	2.25±1.37	2.03*
Block Design	2.54±1.41	2.27±1.38	1.36
Object Assembly	3.97±2.04	3.19±1.84	2.89**

***,*: Significant at 0.05% and 0.01%, respectively*

Table 2. Heritability estimates for perceptual cognitive skills in both districts

Perceptual cognitive skills	Heritability (%)	
	Bhiwani	Hisar
Picture Completion	63	54
Picture Arrangement	57	52
Block Design	61	58
Object Assembly	60	56

4. DISCUSSION

The result of heritability revealed that the contribution of genetic was more as compared to environmental factors for perceptual cognitive abilities in both districts. This finding was similar to the study done by Johnson, et al. [17] stated that genetic influences accounted for 60 to 80% of the variance in the perceptual cognitive abilities of twins and remaining 20-40 per cent variations in perceptual cognitive abilities were due to environmental situations. Another study done by Posthuma, et al. [18] stated that the genetic and environmental influence on cognitive abilities and assessed the four cognitive domains of Wechsler scale and found that the heritability estimate for perceptual cognitive abilities was ranging from 50-70 per cent. Lukowski, et al. [19] previous study of genetic of individual differences in twins on different cognitive abilities found that the working memory cognitive abilities were highly heritable and revealed that half of variance in working memeory cognitive abilities were contribution of genetic material.

Table 3. Correlation coefficient among monozygotic twins and dizygotic twins for perceptual cognitive abilities in both districts

Perceptual cognitive abilities	Correlation Coefficient (r)			
	Bhiwani		Hisar	
	Monozygotic	Dizygotic	Monozygotic	Dizygotic
Picture Completion	0.81	0.49	0.76	0.49
Picture Arrangement	0.71	0.43	0.72	0.45
Block Design	0.62	0.32	0.72	0.43
Object Assembly	0.78	0.48	0.75	0.47

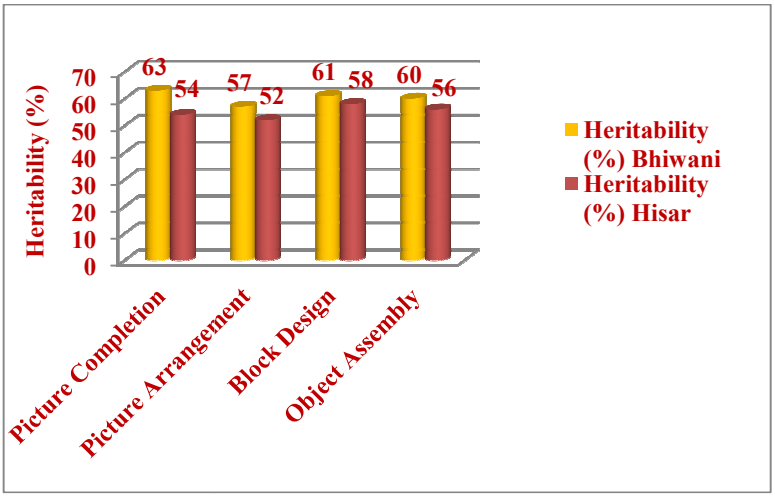

Fig. 1. Heritability estimates for perceptual cognitive skills in both districts

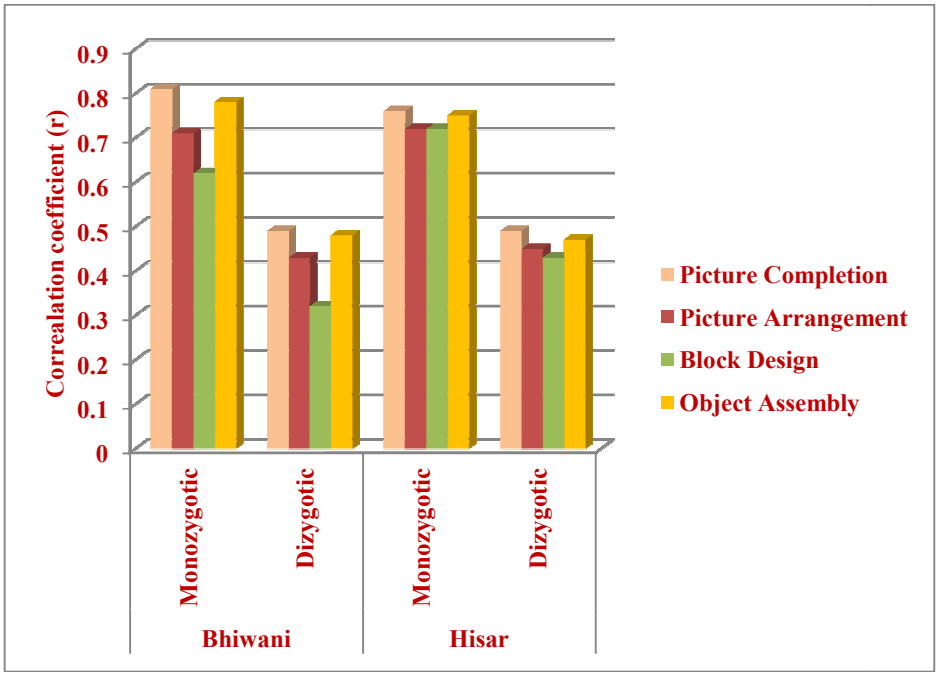

Fig. 2. Correlation coefficient among monozygotic twins and dizygotic twins for general cognitive abilities in both districts

Beam, et al. [20] reported that individual differences in cognitive abilities during early years were genetically and environmentally influenced, which in turn further differentiated individuals by cognitive abilities. Lyons, et al. [21] Suggested that genetic factors influenced level of cognitive functioning and specific cognitive abilities changed differently with age. Rosalind, et al. [22] Reported that cognitive abilities of twins were heritable and observed that the genetic and environmental influences on different developmental patterns of verbal and non-verbal cognitive abilities of twins from the age group 7 to 12 years.

The Table 3 provided information for the correlation coefficient among monozygotic and dizygotic twins for their perceptual cognitive abilities and revealed that the monozygotic twins were more correlated with each other than dizygotic twins for their perceptual cognitive abilities. The similar findings Deary, et al. [23] supported the result that the correlation coefficient of monozygotic twins for perceptual cognitive abilities was 0.86 and correlation coefficient among dizygotic twins was 0.62.

5. CONCLUSION

The variations in perceptual cognitive abilities noted were due to environmental circumstances of twins. The perceptual cognitive abilities of twins were more influenced by genetic factors than the environmental factors. The current study also stated that monozygotic twins were more correlated with each other in perceptual cognitive abilities of twins than the dizygotic twins. The monozygotic twins share 100 per cent genetic constitution whereas dizygotic twins share 50 per cent.

FUNDING

Authors are thankful to Department of Human Development and Family Studies, I.C. College of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, 125004, Haryana, India.

CONSENT AND ETHICAL APPROVAL

The experiments on twins were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all twins and their parents. All experimental protocols were approved by Institution advisory Committee at Chaudhary Charan Singh Haryana Agricultural University and were performed in accordance with the guidelines formulated by the advisory committee.

ACKNOWLEDGEMENT

I express my deep sense of gratitude to my speculative prudent and dignified revered guide Dr. Bimla Dhanda, Professor cum Dean, I.C college of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, for her valuable and gifted guidance, keen interest, unfailing source of inspiration, critical supervision and painstaking efforts during the entire course of study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tucker-Drob EM, Briley DA, Harden KP. Genetic and environmental influences on cognition across development and context. Current Directions in Psychological Science. 2013; 22(5):349.
2. McGue M, Christensen K. Growing old but not growing apart: Twin similarity in the latter half of the lifespan. Behav Genet. 2013;43(1):1-12.
3. Ropers HH. Genetics of early onset cognitive impairment. Annual Review of Genomics and Human Genetics 2010;11: 161–187.
4. Van Dongen J, Slagboom PE, Draisma HH, Martin NG and Boomsma DI. The continuing value of twin studies in the omics era. Nat Rev Genet. 2012;13(9): 640-653.
5. Elliot M, Tucker-Drob EM, Briley DA, Harden KP. Genetic and environmental influences on cognition across development and context. Current Dir. Psychological Science. 2013;22(5):349–355.
6. Morris TT, Davies NM, Dorling D, Richmond RC, Smith GD. Testing the validity of value-added measures of educational progress with genetic data. Br Educ Res J. 2018;44(5):725–747.
7. Haworth CMA, Wright MJ, Martin NW, Martin NG, Boomsma DI, Bartels M, et al. A twin study of the genetics of high cognitive ability selected from 11,000 twin pairs in six studies from four countries. Behav Genet. 2009;39(4):359–370.
8. Okbay A, Beauchamp JP, Fontana MA, Lee JJ, Pers TH, Rietveld CA, Oskarsson S. Genome-wide association study identifies 74 loci associated with educational attainment. Nature. 2016;533: 539–542.
9. Tucker-Drob EM, Briley DA. Continuity of genetic and environmental influences on cognition across the life span: A meta-analysis of longitudinal twin and adoption studies. Psychological Bulletin. 2014; 140(4):949.
10. Anokhin AP, Golosheykin S, Grant JD and Heath AC. Heritability of brain activity related to response inhibition: A longitudinal genetic study in adolescent twins. Int J Psychophysiol. 2017;115:112–124.
11. Heiland F. Does the birth order affect the cognitive development of a child? Applied Economics. 2009;41(14):1799-1818.
12. Haworth CMA, Wright MJ, Martin NW, Martin NG, Boomsma DI, Bartels M, et al. The heritability of general cognitive ability increases linearly from childhood to young adulthood. Molecular Psychiatry. 2010;15: 1112-1120.
13. Mitchell MB, Cimino CR, Benitez A, Brown CL, Gibbons LE, Kennison RF, et al. Cognitively stimulating activities: effects on cognition across four studies with up to 21 years of longitudinal data. Journal of Aging Research. 2012;1-12.
14. DeFeries J, Yang J, Davis OP, Visscher P and Plomin R. DNA evidence for strong genome- wide pleiotropy of cognitive and learning abilities. Behavior Genetics. 2013; 1-7.
15. Wechsler D. Wechsler intelligence scale for children (revised edition). New York: The Psychological Corporation. 1974;1-191.
16. Falconer DS. The Ronald Press Co., New York, USA. 1960;36.
17. Johnson W, Bouchard TJ, Mcgue M and Segal NL. Genetic and environmental influences on the Verbal-Perceptual-Image Rotation (VPR) model of the structure of mental abilities in the Minnesota study of twins reared apart. Intelligence. 2007; 35(6):542-562.
18. Posthuma D, Baare´ WF, Hulshoff Pol HE, Kahn RS, Boomsma DI, De Geus EJC: Genetic correlations between brain volumes and the WAIS-III dimensions of verbal comprehension, working memory, perceptual organization, and processing speed. Twin Res. 2003;6:131– 139.
19. Lukowski SL, Soden B, Hart SA, Thompson LA, Kovas Y, Petrill SA.

Etiological distinction of working memory components in relation to mathematics. Intelligence. 2014;47:54-62.
20. Beam CR, Turkheimer E, Dickens WT, Davis DW. Twin differentiation of cognitive ability through phenotype to environment transmission: The Louisville Twin Study. Behavior Genetics. 2015;1-13.
21. Lyons MJ, Panizzon MS, Liu W, McKenzie R, Bluestone NJ, Grant MD, et al. A longitudinal twin study of general cognitive ability over four decades. Dev Psychol. 2017;53(6):1170–1177.
22. Rosalind YZ, Rijsdijk, Corley R. Differential environmental influences on the development of cognitive abilities during childhood, intelligence. Elsevier. 2018; 66(C):26-39.
23. Deary J, Spinath FM, Bates TC. Genetics of intelligence. European Journal of Human Genetics. 2006;14:690–700.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60723