



Research Article

GENETIC AND ENVIRONMENT INFLUENCES ON THE COGNITIVE ABILITIES: STUDY OF 6-TO-8 YEARS TWINS

ANNU¹ AND BIMLA DHANDA²

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

²Dean and Professor, I.C. College of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, 125004, Haryana, India

*Corresponding Author: Email - annupanghal1997@gmail.com

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Abstract: This research paper aims to determine genetic-environment influences on the cognitive abilities of twins. Using the 100 pairs of twins from two districts, namely: Bhiwani (N = 90) and Hisar (N = 110) of Haryana State. Genetic and environmental influences were assessed in twin study design. The cognitive abilities of twins were measured using the Wechsler Intelligence Scale for Children (WISC-R). Home Observation for Measurement of the Environment (HOME) Inventory was taken to examine the home environment of twins. Heritability estimate was used to analyze the genes contributing to shape the cognitive abilities of twins. The heritability estimates for cognitive abilities of 6-7 years old twins in Hisar district were 74% and in Bhiwani District 76%. Further the heritability estimates were 64% in the twins of Hisar district and 60% in Bhiwani district in the age group of 7-8 years. The remaining variations in the cognitive abilities of twins were due to environmental factors namely: provision for active stimulation and family participation in developmentally stimulating experiences. The findings provide robust evidence that the cognitive abilities were more influenced by genes than the environmental factors and also revealed that the influence of genetic was more in the age group 6-7 years than the age group 7-8 years. The conclusion of the heritability estimates indicates that the genetic influence was more in the age group of 6-7 years than the age group of 7-8 years.

Keywords: Genetics, Heritability, Twins, Environment, Cognitive abilities

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Introduction

The genes are responsible for the substantial heritability of cognitive abilities of twins. Genes are the suppliers of specific traits. The environment consists of external circumstances like culture, social and life experience. Heredity is the process of transmission of characteristics from one generation to another. Heritability is defined as mathematical estimate to find out variations in traits in individuals due to genetic factors. Many twin studies revealed that the heritability of cognitive abilities is ranging between 20% and 80% from infancy to adulthood [1]. They conducted twin study to examine the genetic influence on cognitive abilities and concluded that 50-60% of variance in cognitive abilities twins due to genetic factors [2]. The genetic variance increases with increasing age and affect all cognitive abilities [3].

Genetic factors interact with a person's family and cultural environment which turns in person's genotype [4]. The genetic play a significant role in constructs the cognitive abilities [5]. In first 16 years of life, both genetic and environmental factors have powerful influence in the cognitive ability whereas each and every age is influence by genetic factors and environment influence throughout the life span [6]. The roles of genetics and the environment have been central to theories of cognitive ability as all human beings have some influence of environment on the development of cognition through gene-environment interplay with systematic ways [7].

The environmental influences on general cognitive abilities and heritability of complex dimensions were likely to be due to several genes with special effects [8]. The genetic effects on diverse cognitive abilities were general rather than specific or modular. General cognitive ability (g), a key factor in learning and memory, was among the most heritable behavioral traits [9]. The individual differences in cognitive abilities during early years were genetically and environmentally influenced, which in turn further differentiated individuals by cognitive abilities.

The genetic factors influenced level of cognitive functioning and specific cognitive abilities changed differently with age. In the twin study it was found that the verbal and nonverbal cognitive abilities of twins were influenced by genetic and environmental factors [10].

Material and Methods

Study Design

The aim of twin study was to find out heredity and environmental influences on cognitive abilities. The study was carried out in two districts namely: Bhiwani (N = 90) and Hisar (N = 110) of Haryana state. To assess the cognitive abilities of twins, total 100 pairs of twins were selected from two districts with the age group 6-to-8 years.

Data collection

Data were collected by assessment, interview, observation and questionnaire method from the twins and their parents to gather information.

Tool

The cognition of twins was examined by the WISC-R [11] and it is applicable on normal and abnormal children with both sexes and any socio-economic status of children's family. The home environment of twins was analysed by HOME inventory [12] and it analysed the social, emotional and cognitive support provide by family members to their children.

Statistical Analysis

The statistical analysis performed in software SPSS (Statistical Package for the Social Sciences). Mean, Standard Deviation, z-test, Chi square and heritable estimate were used to meet the objectives of the study. Heritability estimates (h^2) were calculated by the following formula given by [13].

Table-1 Cognitive dimensions of monozygotic and dizygotic twins (N = 200)

Dimensions of cognitive	Monozygotic		Z Value	Dizygotic		Z Value
	Bhiwani (n = 62) Mean±SD	Hisar (n = 78) Mean±SD		Bhiwani (n = 28) Mean±SD	Hisar (n = 32) Mean±SD	
Information	6.15±2.98	5.77±2.28	0.83	6.68±2.51	5.22±2.18	2.39*
Picture Completion	4.06±1.66	3.81±2.15	0.78	4.61±2.22	3.91±2.16	1.23
Similarities	2.55±2.05	1.81±1.64	2.31*	3.00±2.24	1.56±1.29	2.99**
Digit Span	8.92±2.66	8.03±2.14	2.14*	9.50±2.53	8.47±2.83	1.49
Mazes	5.47±2.28	4.77±2.20	1.83	5.57±2.43	4.94±2.30	1.03
Picture Arrangement	2.65±1.39	2.14±1.36	2.18*	2.64±1.22	2.50±1.37	0.42
Arithmetic	2.07±0.79	1.81±0.69	2.04*	2.16±0.65	1.80±0.73	2.02*
Block Design	2.63±1.35	2.21±1.42	1.79	2.36±1.54	2.44±1.29	0.22
Vocabulary	10.90±4.12	10.09±4.64	1.09	11.39±3.82	10.38±4.51	0.94
Object Assembly	4.16±2.04	3.15±1.93	2.98**	3.57±1.99	3.25±1.63	0.68
Comprehension	7.27±2.60	6.23±2.53	2.38*	8.07±2.77	6.25±2.64	2.60**
Coding	46.35±0.89	45.86±0.92	3.19**	40.18±0.86	41.28±0.89	4.86**
Total	103.19±16.81	95.67±16.53	2.65**	105.73±18.53	96.98±19.14	1.8

$$h^2 = 2(RMz - RDz)$$

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 intellectual abilities of twins.

Result

Cognitive Dimensions of Monozygotic and Dizygotic Twins

[Table-1] revealed highly significant differences in mean values for object assembly ($Z=2.98^{**}$), coding ($Z=3.19^{**}$) and total cognitive ($Z=2.65^{**}$) dimensions of cognitive in monozygotic twins of two locations, while in dizygotic twins, more significant differences were found on similarities ($Z=2.99^{**}$), comprehension ($Z=2.60^{**}$) and coding ($Z=26.97^{**}$) dimensions of cognitive. The significant differences were also found between Bhiwani and Hisar locations for monozygotic twins on dimensions of cognitive, namely, similarities ($Z=2.31^*$), digit span ($Z=2.14^*$), picture arrangement ($Z=2.18^*$), arithmetic ($Z=2.04^*$) and comprehension ($Z=2.38^*$), while for dizygotic twins on information ($Z=2.39^*$) and arithmetic ($Z=2.02^*$), but non-significant differences were found for remaining dimensions namely, picture completion, mazes, block design and vocabulary over two districts. Twins at Bhiwani districts performed better than Hisar district for all the same mentioned dimensions.

Heritability estimates for cognitive abilities of twins over districts

[Table-2] indicated the heritability estimates for cognitive abilities in Bhiwani district was 71.00 percent. The interpretation of data clearly showed that the remaining 29 percent variance in cognitive abilities in Bhiwani district was attributed to environmental factors. The heritability estimates for cognitive abilities in Hisar district was (69.00%) and remaining 31 percent variance in cognitive abilities of twins was due to environment. The findings on heritability estimates showed that the genetic influence on cognitive abilities of twins for Bhiwani district was more than the environment. Similar results were obtained in Hisar district. The heritability estimates also indicated that the genetic influence on cognitive abilities was more in Bhiwani district as compared to Hisar district. The heritability estimates for cognitive abilities of twins was 76.00 percent in the age group 6-7 years that clearly indicated that the remaining 24 percent variance in cognitive abilities of twins was attributed to environmental factors in Bhiwani district. But heritability estimates were 60.00 percent in the age group 7-8 years and the remaining 40 percent variance was due to environmental factors in Bhiwani district. In Hisar district the heritability estimates for cognitive abilities in the age group 6-7 years was 74.00 percent and only 26 percent variance in cognitive abilities of twins in the same age group was attributed to environmental factors where in the age group 7-8 years the heritability estimates were 64.00 percent. The interpretation of data clearly indicated that whereas 36 percent influence of environment on cognitive abilities in the age group 7-8 years in Hisar district. On the conclusion of the heritability estimates showed that reverse trend with regard to the genetic influence on cognitive abilities of twins as decreasing of scores on heritability estimates with increasing age of the twins.

Table-2 Heritability estimates for cognitive abilities of twins over locations

District	Heritability (%)		
	6-7 Years	7-8 Years	Total
Bhiwani	76	60	71
Hisar	74	64	69

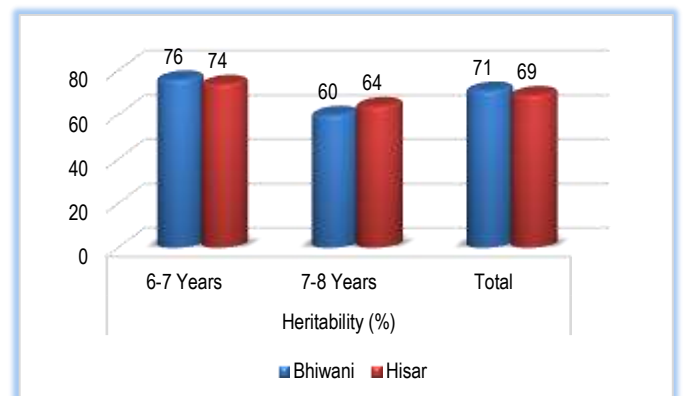


Fig-1 Heritability estimates for cognitive abilities of twins over locations

Associations of cognitive abilities with home environment in Hisar district

[Table-3] revealed that the cognitive abilities of twins were associated with dimensions of home environment, namely, provision for active stimulation ($\chi^2 = 13.01^*$), family participation in developmentally stimulating experiences ($\chi^2 = 21.85$) at Hisar district.

Table-3 Associations of cognition with home environment in Hisar district

Cognitive abilities				
Home Environment	Low	High	Total	χ^2
Provision for Active Stimulation				
Below average	79	15	94	13.01*
Above average	7	9	16	
Total	86	24	110	
Family Participation in Developmentally Stimulating Experiences				
Below average	63	5	68	21.85*
Above average	23	19	42	
Total	86	24	110	

Table-4 Associations of cognition with home environment in Bhiwani district

Cognitive abilities				
Home Environment	Low	High	Total	χ^2
Provision for Active Stimulation				
Below average	42	18	60	4.63*
Above average	14	16	30	
Total	56	34	90	
Family Participation in Developmentally Stimulating Experiences				
Below average	32	9	41	8.02*
Above average	24	25	49	
Total	56	34	90	

Associations of cognitive abilities with home environment in Bhiwani district

[Table-4] revealed that the cognitive abilities of twins were associated with dimensions of home environment, namely, provision for active stimulation ($\chi^2 = 4.63^*$), family participation in developmentally stimulating experiences ($\chi^2 = 8.02^*$) at Bhiwani district.

Discussion

The similar study supported that genetic difference between people account for 50% to 70% of the variation in performance on tests of cognitive abilities [14]. The genetic influences account for over 60% of the variance in cognitive outcome of twins, with environmental influences accounting for the remaining variance [15]. The findings on heritability estimates showed that the genetic influence on cognitive abilities of twins was more with the age group 6-7 years as compared to age group 7-8 years. The other similar finding supported this finding that genetic factors play an important role in shaping the verbal cognitive abilities of twins [16]. The early environment is associated with twins' cognitive development and may be more strongly associated with their verbal than nonverbal skills. They also suggested that the level of parental education and the amount of cognitive stimulation from parents had a greater influence on twins' verbal than nonverbal skills [17]. The environmental factors affect the cognitive abilities of twins [18]. Some studies concluded that in early childhood one of the main factors that affecting child cognitive development was the family environment, which included both care and stimulation provided to children by the caregivers, and the socioeconomic status (SES) of the family [19].

The significant effects of the physical environment such as toxins, pollutants, noise, crowding, housing, school and neighbourhood quality on children's cognitive development and suggested that the physical environment experienced by children impacted their cognitive development across the lifespan, from the prenatal period through adulthood [20]. The impact of family structure and income on the cognitive development and concluded that warm parent-child interactions, a stress-free home environment and positive parental aspirations for their children were strong determinants of the cognitive development of young children [21-23].

Conclusion

The study of twins has provided compelling evidence of the ubiquitous influence of heredity and environment on the cognitive abilities of twins. The cognitive abilities of twins were more influenced by the genetic than the home environment of twins in both districts. The genetic influence on cognitive abilities of twins was more in the age group 6-7 years as compared to the age group 7-8 years. It was the present study found that the genetic influence was more in Bhiwani district as compared to the Hisar district. Regarding the home environment of twins, it was found better in Hisar district as compared to Bhiwani district. The heritability estimates revealed the genetic impact was more in the twins with the age group of 6-7 years as compared to the 7-8 years old twins and it clearly revealed that the genetic influence was more in early years of life than the later years of life.

Application of research

The statistical power of genetic study enhances by reducing the amount of variations of genetic or environment through the use of twins in the study. Twin studies analyse the overall role of genes in development of traits. The comparison between monozygotic twins and dizygotic twins evaluate the degree of genetic and environmental influence on a specific trait.

Research Category: Human Genetics, Environmental factors

Abbreviations: HOME- Home Observation for Measurement of the Environment

h^2 - Heritability Estimate, SES- Socioeconomic Status

RMz- Correlation Coefficient for Monozygotic Twin Pairs

RDz- Correlation Coefficient for Dizygotic Twins Pairs

SPSS- Statistical Package for the Social Sciences

SD- Standard Deviation

WISC-R- Wechsler Intelligence Scale for Children-Revised

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Study area / Sample Collection: Bhiwani and Hisar

Cultivar / Variety name: Nil

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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