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Genetic and Environmental Analysis for Verbal and Non-verbal Intelligence of 5-6 Years Twins: An Intervention Study

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ABSTRACT: The genetic variations accounted for around 60-70% in verbal and non-verbal intelligence of twins during early childhood. Intelligence is mental ability of a person towards planning, reasoning, problem-solving, abstract thinking, quick learning and learning through experiences. The main aim of twin investigation was to analyse the genetic and environmental variations in verbal and non-verbal intelligence of twins to assess the impact of intervention on intelligence of twins. The study was planned to examine the how much of variations in verbal and non-verbal intelligence of twins from the age 5-6 years due to genetic and environmental factors and assess the impact of intervention programme on intelligence of twins. Twin research was conducted in Bhiwani and Hisar district of Haryana state. Twins with age group of 5-6 years was selected from villages of Bhiwani district and Hisar district. Intelligence of twins was examined with help of Stanford Binet Intelligence Scale (Terman and Merrill 1960), whereas home environment of twins was measured by using the Home Observation for Measurement of the Environment (HOME) (Caldwell and Bradley, 1984). Results of present twin study revealed that the significant difference in mean values was observed on age 5-6 years for non-verbal intelligence of twins in Bhiwani and Hisar district on the basis of standard test. The findings on heritability estimates showed that the influence of genetic material on verbal and non-verbal intelligence level of twins was more than the environment in both districts. The contribution of genetics was more on verbal intelligence of twins than non-verbal intelligence of twins. Home environment of twins improve the intellectual abilities of twins in early childhood period. The findings of twin study revealed that identical twins were more correlated with each other as compared to fraternal twins for their both verbal and non-verbal intelligence. The result showed that significant increase in intelligence level of twins due to several activities related to intelligence provided through the intervention programme. Intervention programme was also responsible to improve the intelligence of twins.

Keywords: Verbal intelligence, Non-verbal intelligence, Genetics, Environment and Twins.

INTRODUCTION

Intelligence is a psychological trait that inculcates many behavioural and psychological consequences, including educational status, occupational status, health and longevity (Deary, 2012). Intelligence may be defined as the capability of an individual such as problem solving, reasoning and learning. Intelligence is the most important trait than any other trait to predict the outcomes of education, occupation and health and is highly heritable (von Stumm and Plomin 2015).

The several studies of behavioural genetic, comprising of identical and fraternal twins, are used to examine how much of variations in human abilities like intelligence which is the outcome of both genetic propensities and environmental circumstances. Twin study is the foremost method useful in quantitative genetics to evaluate the individual differences due to genetic material and environmental situations. The twin investigation needs both identical and non-identical twins because the comparison between these twins indicated that differences were due to genetic and environmental influences at particular time (Hawortha *et al.*, 2008). The twin research designs govern causal interrelationships between brain function and structure, neuropsychological performance (Blokland *et al.*, 2017).

The twin investigations give a framework to analyse the contribution of heritability between pairs of identical twins, who share 100 per cent of their genetic material, and non-identical twins, who on average share 50 per cent of their segregating gene. Heritability is a statistics that describes the amount of variance in a trait that can be attributed to genetic differences in a given population (Malanchini *et al.*, 2020). It is not a constant value and varies for a trait depending on developmental

processes like neonate, child and adult (Greenspan, 2022). Monozygotic twins disclosed fairly closer similarities than dizygotic twin pairs as increase in the age of twins and that showed that the impact of genetics on variation in particular trait as the actual difference between these two kinds of twins and identical twins are twice as similar genetically (Herle *et al.,* 2017). The genetic studies like behaviour genetics focused on the fact that the contribution and influence of various genes vary at different ages of life as various genes influential in early years but some are influential at later years of life (King *et al.,* 2019).

Around 50 % of variation in level of intelligence of person was due to impact of genetic material (Deary *et al.,* 2009). The impacts of both genetic and environment on intellectual traits are dynamic as they change and shift as change in developmental patterns (Zheng *et al.,* 2019). Mitchell *et al.* (2012) gave suggestion across four longitudinal studies that changed in everyday intellectual activities with variation in various aspects of intellectual abilities were concomitant with relative change in intellectual performance. Austerberry *et al.* (2022) assessed the intelligence level and revealed that intelligence is highly heritable. Moreover, the verbal performances in early and middle childhood are early manifestations of genetic effects on later intellectual performance.

Twin studies suggested that the variance in verbal and non-verbal intelligence is linked to genetically frame work because genetics may largely responsible than environmental factor in determining intelligence of individual (Zheng *et al.,* 2018). The effect of the environment depends on genetic variations, individual differences in intellectual abilities that result from environmental circumstances may come to be attributable to genetic endowment Rhemtulla and Tucker-Drob (2012). Dickens and Flynn (2001) have suggested that recurrence of environmental experience is a core necessity of intellectual development. Assary *et al*. (2020) investigated the genetic architecture of environmental sensitivity by estimating its heritability and suggested that heritability of sensitivity was 0.47 and individual differences in susceptibility to environmental influences have a genetic basis. Oommen (2014) revealed that nature engaged largely in determining Intelligence Quotient (IQ), various other modifiable nurture influences could influence the IQ of an individual. Nature and nurture worked dependently in shaping the intellectual level of human being.

Orri *et al.* (2019) found that the intervention positively impacted different home environment dimensions but these changes did not account for improvements in children's outcomes. They did not find that these positive changes in the home environment translated into improvements in children's intelligence at 5 years of age. Burgoyne *et al.* (2020) designed intervention to alter the genetic and environmental contribution on psychological traits and found that designed interventions might be occasionally exerting their effects by changing the contribution of genetics on psychological traits.

MATERIALS AND METHODS

Study Design: This twin investigation was conducted by using descriptive and experimental research design. The aim of twin research was to assess the impact of genetic propensity and environmental factors on verbal and non-verbal intelligence of twins. Twin study was conducted in Bhiwani and Hisar District of Haryana state. The verbal and non-verbal intelligence of twins with the age group 5-6 years was assessed. Intervention Programme was developed and implemented in home-settings of twins in both Bhiwani and Hisar District.

Data collection: The data was collected by interview and questionnaire methods from the twins and parents of twins to gather relevant information. The snow ball sampling was also used to collect the twins in the required age group of twins.

Tool: Stanford Binet Intelligence Scale (Terman and Merrill 1960) was used to examine the verbal and non-verbal intelligence of twins. The home environment of twins was assessed through Home Observation for Measurement of the Environment (HOME) given by Caldwell and Bradley, 1984.

Statistical Analysis: The software SPSS (Statistical Package for the Social Sciences) was used to analyze the data and to draw inferences. Mean, Standard Deviation, z-test, t-test, Increase in Percentage, Chi-square test and Heritable estimate were used to examine the main objective of the twin investigation. Heritability estimates (h^2) were calculated by the following formula given by Falconer (1960), $h^2 = 2(RMz - RDz)$ 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.

Research finding. The results obtained from the present twin study have been summarized under following heads:

Comparison of verbal and non-verbal intelligence of twins from 5-6 years

As data presented in Table 1 there were significant (0.05%) difference in mean values was observed on age 5-6 years (Z=2.43*) for non-verbal intellectual of twins, but no significant difference in mean values was found on age 5-6 years (Z=0.90) for verbal intelligence of twins in both Bhiwani and Hisar district.

Table 1: Comparison of verbal and non-verbal intelligence level of twins from 5-6 years.

Age (in years)	Verbal intelligence		
	Bhiwani	Hisar	Z value
5-6	39.11±13.27	36.77±12.77	0.90
Non-verbal intelligence			
5-6	26.05±8.16	21.95±8.69	2.43*

Heritability estimates for verbal and non-verbal intelligence of twins with the age group 5-6 years. The data in Table 2 indicated that the heritability estimates for verbal intelligence of twins with the age group 5-6 years was 71.00 per cent and the remaining 29.00 per cent variations in verbal intelligence of twins were due to environmental factors in Bhiwani district. Further this table also revealed that the heritability estimates for verbal intelligence of twins was 60.00 per cent and remaining 40.00 per cent variations in verbal intelligence of twins was attributed to environmental factors in Hisar district. The heritability estimates for non-verbal intelligence was 68.00 per cent and 59.00 per cent in Bhiwani and Hisar district respectively. The interpretation of data clearly indicated that remaining 32.00 per cent and 41.00 per cent variations in non-verbal intelligence of twins was due to environmental circumstances in Bhiwani and Hisar district respectively. The findings on heritability estimates revealed that the genetic influences were more important source of variation in verbal intelligence of twins as compared to non-verbal intelligence of twins during 5-6 years.

Table 2: Heritability estimates for verbal and non-verbal intelligence of twins with the age group 5-6 years.

District	Verbal Intelligence (%)	Non-verbal Intelligence (%)
Bhiwani	71.0	68.0
Hisar	60.0	59.0

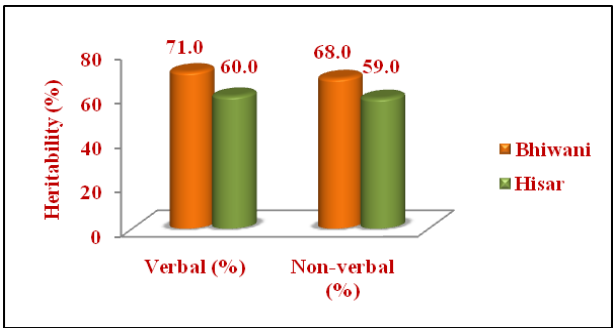

Fig. 1. Heritability estimates for verbal and non-verbal intelligence of twins with the age group 5-6 years.

Correlation co-efficient among monozygotic and dizygotic twins for verbal intelligence in both districts. The data in Table 3 revealed regarding the correlation coefficient of monozygotic and dizygotic twins for verbal and nonverbal intelligence of twins from 5-6 years. The data indicated that the correlation coefficient(r) of monozygotic twins for verbal intelligence was 0.95 in Bhiwani district and 0.64 in Hisar district. Further the data in this table portrait regarding the dizygotic twins, the correlation coefficient(r) was 0.60 and 0.34 in Bhiwani and Hisar district respectively for verbal intelligence of twins during 5-6 years. Further, this table also indicated that the correlation coefficient of monozygotic and dizygotic twins for nonverbal intelligence of twins from 5-6 years, the correlation co-efficient of monozygotic twins was (r=0.64) in Bhiwani district and (r=0.80) in Hisar district, while for dizygotic twins, correlation co-efficient(r) was 0.30 and 0.51 in Bhiwani and Hisar district respectively. The result indicated that the monozygotic twins were more correlated with each other than the dizygotic twins for verbal and nonverbal intelligence of twins.

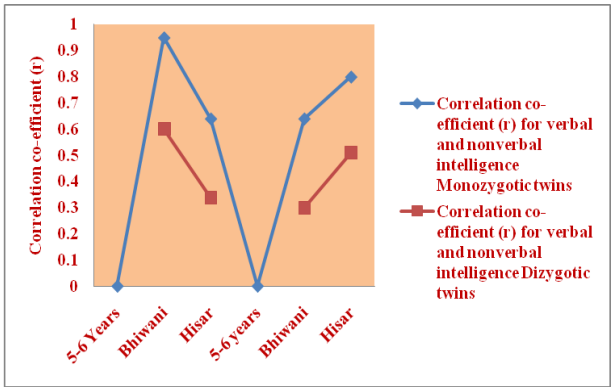

Fig. 2. Correlation co-efficient among monozygotic and dizygotic twins for verbal and nonverbal intelligence.

Association of intelligence of twins with home environment of twins. The data in Table 4 indicated that intelligence of twins was significantly associated with composite home environment of twins ($\chi 2$=6.06*). The data in this table clearly indicated that above average composite home environment of twins associated with moderate level of intelligence.

Table 3: Correlation co-efficient among monozygotic and dizygotic twins for verbal and nonverbal intelligence.

Age Districts	Correlation co-efficient (r) for verbal and nonverbal intelligence	
	Monozygotic twins	Dizygotic twins
5-6 Years	**Verbal Intelligence**	
Bhiwani	0.95	0.60
Hisar	0.64	0.34
5-6 years	**Nonverbal Intelligence**	
Bhiwani	0.64	0.30
Hisar	0.80	0.51

Table 4: Association of intelligence of twins with home environment of twins.

Composite Home environment	Intelligence				
	Low	Moderate	High	Total	$\chi 2$
Below average	19(10.92)	14(8.05)	5(2.87)	38(21.84)	6.06*
Above average	41(23.56)	58(33.33)	37(21.26)	136(78.16)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	

Impact of intervention on intelligence of twins during 5-6 years in two districts. As data presented in Table 5 indicated that the highly significant difference in mean values was observed at age 5-6 years (t=3.40**) of twins in Bhiwani district and at age5-6 years (t=4.70**) in Hisar district. Further the data in this table also showed that increase in mean percentage was observed on age 5-6 years (22.62%) in Bhiwani district and 5-6 years (30.21%) in Hisar district. The data indicated that impact of intervention on intelligence of twins at age 5-6 years was more found in Hisar district as compared to Bhiwani district.

Table 5: Impact of intervention on intelligence of twins during 5-6 years in two districts.

Age (in year)	Bhiwani				Hisar			
	Pre-test (n=10) Mean±SD	Post-test (n=10) Mean±SD	Increase in mean (%)	t Value	Pre-test (n=20) Mean±SD	Post-test (n=20) Mean±SD	Increase in mean (%)	t Value
5-6	38.90±8.75	47.70±12.53	8.8 (22.62)	3.40**	41.05±10.15	53.45±16.68	12.4 (30.21)	4.70**

DISCUSSION

The major findings of twin study stated that the impact of genetics was more on verbal intelligence of twins than non-verbal intelligence of twins. The influence of genetic material was more as compared to environmental factors on both verbal and non-verbal intelligence of twins in both Bhiwani and Hisar district. Indeed, research has acknowledged that verbal and non-verbal intellectual ability as the major source of variation due to genetic factors. The similar results were supported by other twin study; Plomin *et al.* (2013) provided the supportive evidence that heritability estimates are greater for verbal than non-verbal intelligence of twins. The results of present study consistent with Rosalind *et al.* (2018) reported that intelligence of twin was heritable and variation in verbal intelligence of twins was due to genetic predisposition. Spengler *et al.* (2018) provided supportive evidence for this finding that genetic factors are more responsible in shaping the non-verbal cognitive abilities of twins. Zheng *et al.* (2018) conducted a twin studies and portrait that the variance in intelligence is associated to genetics potential. This research of twins revealed that genetics heritage plays a bigger role than environmental circumstances in determining individual intelligence. Franić *et al.* (2014) conducted longitudinal twin study to assess the genetic and environmental contributions to the temporal stability of verbal, non-verbal and general intelligence across a developmental period spanning childhood and adolescence and revealed that the high stability of additive genetic factors for verbal, non-verbal and general intelligence of twins and stability of environment was moderate. Van Soelen *et al.* (2011) assessed the contribution of genetic on verbal and performance intelligence of twins and found that the heritability contribution increased with age for both verbal and performance intelligence. The present study line with Canfield *et al.* (2017) revealed that more genetic influence on verbal and non-verbal intelligence of twins as compared to environmental circumstances. Manzano and Ullén (2018) found that genetic material was significantly associated with intelligence of twins.

The result findings of correlation co-efficient for monozygotic and dizygotic twins indicated that monozygotic twins were more correlated than dizygotic twins in both districts. The present twin study was supported by Knopik *et al*. (2017) study, indicated that heritability of twins compares the similarity of monozygotic and dizygotic twins to estimate genetic and environmental components of variance. However, the classic twin study design portrait that the average 50 per cent of heritability estimate for intelligence of twins. Moreover, they also suggested that intelligence of children is substantially heritable, along with this, classical twin study design also revealed that the heritability estimates for intellectual abilities ranging from 50 per cent to 70 per cent. Deary *et al.* (2013) assessed the stability of intelligence and reported that

intelligence is the most stable psychological trait, with a Pearson correlation coefficient of 0.54.The intellectual The home environment of twins enhanced the intelligence of twins. Another twin studies provided consistent results, Larsen *et al*. (2019) reported monozygotic twins control for genes, gender, age, and aspects of the home and school environment shared by twins and observed that any difference between identical twins in academic outcomes can be attributed to the unique environment. Brant *et al.* (2013) conducted cross-sectional twin study and this study has observed that individuals with higher intelligence, show high environmental influence on intelligence during early childhood. However, the study also emphasized that the individuals with lower intelligence, show high heritability estimate of intelligence. Turkheimer and Horn (2014) evidenced suggest that positive and significant influence of socio-economic status on the heritability estimates of intellectual abilities in childhood. Moreover, the study also depicted that the estimates of genetic variance tend to increase to 50 per cent of total variance in the highest socio-economic status groups. Manley *et al.* (2015) conducted twin study on pre-schoolers and found that the higher maternal education, higher paternal education and caregiver employment, all these three social variables are associated with to enhance the intellectual abilities during preschool years.

The results of present study highlighted that the intervention package highly significantly improved the intelligence scores of twins at age 5-6 years of twins. An intervention study also supported that intervention boost the intellectual level of twins (Torgesen, 2005). Sisk *et al.* (2018) revealed that the individual differences in intelligence can be easily overcome with effective interventions that improve the intelligence of children by focusing on strength and weaknesses of children. Nisbett *et al.* (2012) revealed that improvement in intelligence of twins produced by the most effective early childhood interventions and also suggested that early childhood interventions had remarkable effects on academic achievement and life outcomes. Another study provided the similar results of present intervention study Barnett (2011) revealed that the educational intervention provided during preschool years tend to boost the development of intelligence in early years of life. Moreover, interventions have long-lasting influence on young children with respect to academic achievement, economic productivity and higher education. Similarly, Burgoyne *et al.* (2018) found the genetic contribution to individual differences in mindset became stronger in an environment prior intervention. But after intervention that has become strongly associated with cognitive ability actions raised possibility that may have apprehended with general intelligence following the intervention.

CONCLUSIONS

Twin research concluded as the genetic and environmental variation in verbal and non-verbal intelligence of twins during early childhood, more influenced by genetic propensities than environmental performances like verbal and non-verbal correlate at 0.3 level (Malykh *et al*., 2016).

factors. The genes are more responsible for variations in verbal intelligence of twins than non-verbal intelligence of twins. The impact of genetic material was more as compared to the environmental circumstances. The more similarity in verbal and non-verbal intelligence of twins was in monozygotic twins than dizygotic twins. The home environmental circumstances significantly associated with intelligence of twins in early years of life. The composite home-environmental settings are responsible for enhancement of the intelligence level of twins. Intervention programme was enhanced the intelligence of twins in both Bhiwani and Hisar District.

FUTURE SCOPE

The future scope of twin study is to assess the cross-cultural differences in intelligence of twins at different ages. Examine the contribution of intelligence level of parents in shaping the intellectual abilities of their children by using the standardized scale of Adult Intelligence.

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Conflict of Interest. None.

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