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Research Article

Genetic and environmental basis of processing speed cognitive ability of twins

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Abstract

Processing speed is one of the most essential fundamentals of cognitive abilities. The present investigation was formulated with the aim of the basis of genetic and environment on processing speed of cognitive abilities of twins. 100 pairs of twins with the age group 6-8 years were selected from two districts namely, Bhiwani (N=90) and Hisar (N=110) from the Haryana state. The processing speed of the cognitive abilities of twins was measured using the Wechsler Intelligence Scale for Children- Revised (WISC-R). Heritability estimate was used to analyze the genes expression on processing speed cognitive abilities of twins. The result stated that the heritability estimates for processing speed cognitive abilities of twins were 64 percent and 59 percent in Bhiwani and Hisar districts respectively. The correlation coefficient among monozygotic and dizygotic twins for processing speed cognitive ability of twins was r=0.77 and r=0.45 respectively in the Bhiwani district while in the Hisar district the correlation coefficient among the monozygotic twins and dizygotic twins was r=0.71 and r=0.42, respectively. The results also revealed that the monozygotic twins were more correlated in processing speed cognitive abilities as compared to the dizygotic twins. The processing speed cognitive abilities were more influenced by genetic basis as compared to the environmental factors.

Keywords cognitive abilities, dizygotic twins, environment, genetic, heritability estimate, monozygotic

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Introduction

Processing speed is typically examined by psychomotor and visuomotor performance tasks. It includes the speed of perceiving, encoding, response selection, and memory retrieval to complete a task at the general rate by an individual. Processing speed plays an important role in all cognitive functions with higher levels such as comprehension, reasoning, planning, and learning [1]. It is the manifestation of central nervous system processing speed [2]. The twin study design was usually used to estimate the contribution of genetic and environmental basis to the variations between the variables. The monozygotic or identical twins share 100% genetic material whereas dizygotic twins share 50% genetic material. This twin study design allows discriminating between the variations in the variables due to the genetic and environmental factors [3].

Heritability is a mathematical statistics that usually captures how much of the variation of a trait is attributed to genetic differences. It is not responsible to either capture how many genes are involved or how much of the trait relies exclusively on the genome [4]. Reineberg et al., [5] investigated that the genetic and environmental effects on the functional neural connection were crucial towards developing the intermediate phenotypes between genes and cognitive abilities. The results revealed that the non-shared environmental influence was high, genetic influence was moderate, and shared environmental influence was weak-to-moderate across the neural connections in the brain. It was also reported that the physical and social environments provided by parents, education, and schooling influences IQ development. Both heredity and environment affect the development of intelligence and other cognitive abilities of twins [6].

Plomin and Deary [7] revealed that the heritability of intelligence increases dramatically with age up to adulthood despite the genetic stability in twins. Genetic factors interact with a person's family and cultural environment which turns in a person's genotype [8]. The individual differences in cognitive abilities during the early years are genetically and environmentally influenced, which in turn further differentiate theindividuals by cognitive abilities. The genetic factors influenced the 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 [9].

Polderman et al., [10] concluded that the study of twins provided compelling evidence of the ubiquitous influence of genetics, as well as environments, on important human traits including physiological, psychological, and behavioral traits and disorders. Robinson et al., [11] observed the genetic architecture of diverse cognitive abilities in children and adolescents including the magnitude of common genetic effects and patterns of shared and unique genetic influences.

Methodology

Study design

The objective of twin study design was to analyze the genetic and environmental influence on the processing speed cognitive abilities of twins. To conduct this study mainly two districts were randomly selected namely, Bhiwani (N = 90) and Hisar (N = 110) of Haryana state. To assess the processing speed cognitive abilities of twins, total of 100 pairs of twins were selected from two districts with the age group 6-to-8 years.

Data collection

The data was collected from the twins by following assessment, interview, observation, and questionnaire method to gather the valuable information.

Tool

The cognition of twins was examined by The WISC-R [12]. The processing speed subset included coding.

Statistical analysis

The software SPSS (Statistical Package for the Social Sciences) was used for statistical analysis. Mean, Standard Deviation, z-test, and heritable estimate were used to meet the objectives of the study. Heritability estimates (h^2) were calculated by the following formula given by Falconer [13], 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. The correlation coefficient was used to find the correlation between the working memories of twins.

Results

Cognitive dimension of twins in two districts

As presented in Table 1, there were significant (0.05%) differences in the mean values for cognitive dimensions, namely, coding (Z=2.49*) in both Bhiwani and Hisar districts. Twins at Bhiwani district performed better for this parameter as compared to their counterparts from Hisar district.

Table 1. Cognitive dimension of twins in two districts (N=200)

Cognitive Dimensions	Bhiwani (n=90) Mean±SD	Hisar (n=110) Mean±SD	Z Value
Coding	46.30±0.88	45.98±0.93	2.49*

: Significant at 0.05%.

Heritability estimate of processing the speed cognitive ability of twins

The Table 2 portrait regarding the heritability estimate for processing the speed cognitive ability of twins in both districts namely: Bhiwani and Hisar. The heritability estimate for processing the speed cognitive ability namely: coding was 64% in Bhiwani district. The data indicated that the remaining 36 percent variance in coding processing speed cognitive ability was due to environmental factors. In Hisar district, the heritability estimate for coding processing speed was 59 percent, where the remaining 41 percent variance in coding processing speed cognitive ability was due to the environmental factors. The genetic influence was more on coding processing speed cognitive ability in the Bhiwani district as compared to Hisar district.

Table 2. Heritability Estimate of Processing speed cognitive ability of twins

District	Heritability (%) Processing Speed (Coding)
Bhiwani	64
Hisar	59

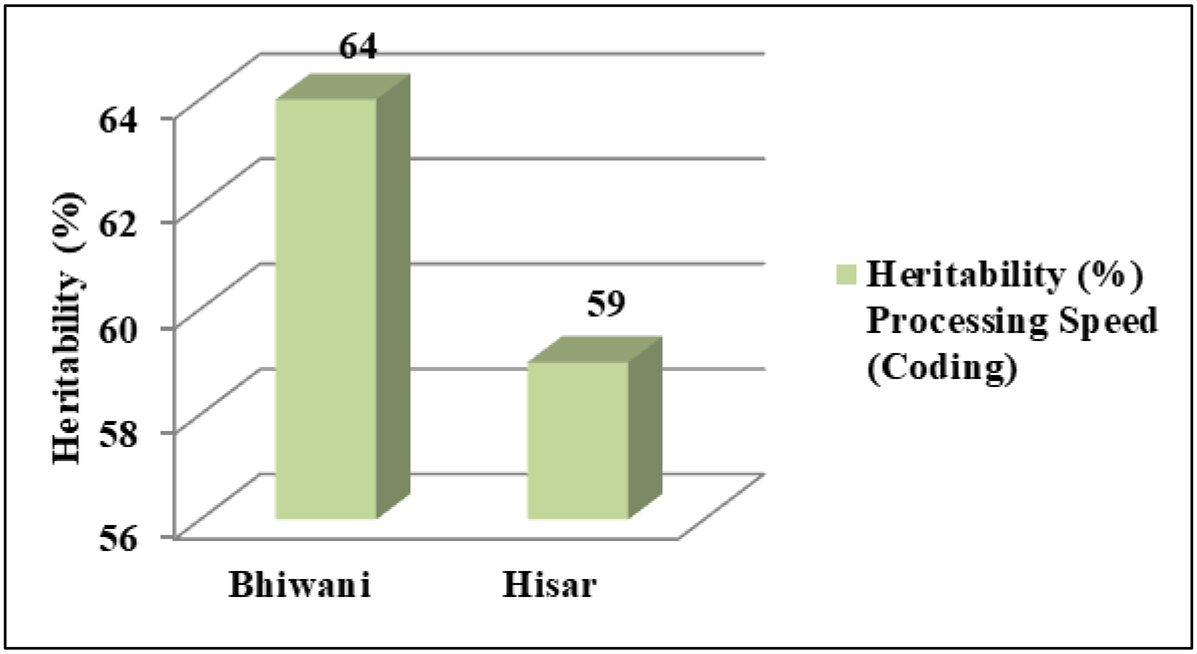

Figure 1. Heritability Estimate of Processing speed cognitive ability of twins

Correlation coefficient among monozygotic and dizygotic twins for processing speed cognitive ability

The Table 3 provided the information regarding the correlation coefficient among monozygotic and dizygotic twins for processing speed in Bhiwani and Hisar district. The data in Table 3 portrays the correlation coefficient among monozygotic twins for processing speed namely: Coding was r=0.77 in the Bhiwani district. Among dizygotic twins, the correlation coefficient for coding was r=0.45 in the Bhiwani district. Further, the correlation coefficient among monozygotic and dizygotic twins for processing speed was r=0.71 and r=42 respectively in Hisar district. The data indicated that monozygotic twins were more correlated with each other in processing as compared to dizygotic twins in both Bhiwani and Hisar district.

Discussion

The heritability estimates for processing speed were 59% and 64% in Bhiwani and Hisar district respectively. The similar findings stated that the heritability estimate for the processing speed of twins was up to 71%. The heritability estimates indicated the genetic influence on the processing speed of the twins and revealed that the genetic influence that accounted for the processing speed was 71 percent and the remaining 29 percent variations in processing speed was contributed to environmental factors [14]. Other similar findings stated that the processing speed cognitive function was highly heritable and the result of the heritability estimate revealed that the heritability estimate was 59%-74% for the processing speed of twins [15].

Table 3. Correlation coefficient among monozygotic and dizygotic twins for processing speed cognitive ability

Processing speed cognitive ability	Correlation Coefficient (r)			
	Bhiwani		Hisar	
	Monozygotic	Dizygotic	Monozygotic	Dizygotic
Coding	0.77	0.45	0.71	0.42

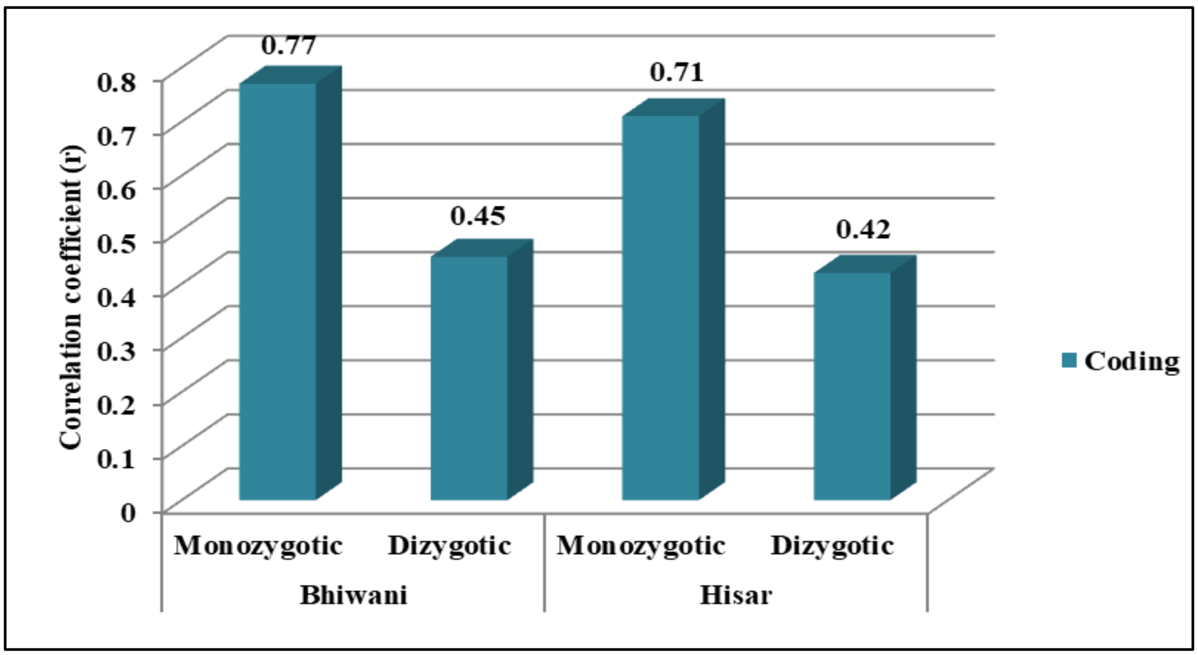

Figure 2. (A) Correlation coefficient among monozygotic and dizygotic twins for processing speed cognitive ability

Tucker-Drob et al., [16] revealed that genetic influences on cognitive development occur through a transactional process, in which genetic predispositions led children to remind cognitively stimulating experiences from their environments. Hellard and Steen [17] revealed the contribution of genetics in cognitive traits and found that the human cognition was strongly imprinted by heritability. Panizzon et al., [18] indicated that general cognitive abilities were highly heritable (86%) and genetics affected the specific cognitive domains.

Hansell et al., [4] used the classical twin model to estimate the heritability for intelligence (IQ), reasoning, and working memory in a twin and sibling sample. The results indicated that genetic material affects the cognitive abilities of twins. The similar findings supported the result that the heritability estimate of cognitive abilities was 40-60 percent [19].

The result of the correlation coefficient of monozygotic twins and dizygotic twins indicated that the monozygotic twins were more correlated with each other than the dizygotic twins. The similar findings were reported stating that the cognitive abilities of monozygotic or identical twins were more similar than dizygotic or fraternal twins [20]. Trzaskowski et al., [21] showed that the genetic correlations between diverse tests of verbal and nonverbal cognitive abilities are greater than 0.50.

Conclusion

The result of the twin study revealed that the processing speed cognitive abilities of twins were more influenced by genetic factors as compared to environmental factors in both Bhiwani and Hisar districts of Haryana State. As monozygotic twins share 100% of their genes whereas dizygotic twins share 50% genetic material, the correlation coefficient among monozygotic and dizygotic twins results revealed that monozygotic twins are more correlated than dizygotic twins for their processing speed cognitive abilities of twins.

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