Human Nature Journal of Social Sciences
Vol.4, No.1 (March, 2023), Pp.495-504
ISSN(online): 2788-5240, ISSN(print):2788-5232

Human Nature Research Publisher

Original Article **http://hnpublisher.com**

Impact of Maternal Education on Fluid Intelligence, Working Memory, Short Term Memory and Processing Speed of School Students

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ABSTRACT

Aim of the Study: Present study aimed to explore the impact of mother's education level on core cognitive functions like working memory, processing speed, short term memory and fluid intelligence.

Methodology: A sample of 300 students (boys=150, girls=150) studying in 9th, 10th, and O Level, with age range 15-16 years were selected from schools by using two stage cluster sampling technique. Correlational and comparative research design was used for the present study. Demographic information form was used to collect personal, educational, and familial information of participants. Working memory index, processing speed index, digit span from WICS-IV and Standard Progressive Matrices were used to assess working memory capacity, information processing speed, short term memory and fluid intelligence. After getting consent from participants to participate in the study, all study variables were assessed with face-to-face interaction in individual setting. Collected data was arranged and analyzed using SPSS version 27.

Findings: After checking the normality of the collected data, Pearson correlation was used to find the association of study variables with one another and MANOVA was used to assess the impact of mother's education on study variables. Results showed significant correlation among fluid intelligence, working memory, short term memory and processing speed. Results revealed significant impact of Mother's education on all study variables.

Conclusion: According to results, highly significant difference was found between the levels of mother's education on the mean score of the students on all study variables. Students with more educated mothers showed better working memory, fluid intelligence, processing speed and short-term memory. The findings of the present study provide in depth and detailed information to educationist, educational Psychologists and parents about the development of core cognitive processes.

Keywords: Fluid Intelligence, Working Memory, Processing Speed, Short-Term Memory.

Article History

Received:
December 15, 2022

Revised:
March 21, 2023

Accepted:
March 26, 2023

Published:
March 30, 2023

Introduction

"Give me an educated mother, I shall promise you the birth of a civilized, educated nation", said Napoleon Buonaparte in the 18th Century. A mother's education level has a long-lasting effect on her child's cognitive, social development. Maternal education also has an impact on the growth of the children (Javid & Pu, 2020). Not as much is known about the impact of demographic variables like parental education and environment on the capacity to reason, remembering, information processing and working memory capacity (Baddeley, 2000). Present study aimed to explore the impact of mother's education level on core cognitive functions like working memory, processing speed, short term memory and fluid intelligence.

The capacity to behave in a flexible manner, or adapt actions as the demands of a changing environment, is an essential part of human cognition. However, in some instances, infants, children, and adults are unable to behave in a flexible manner and instead perseverate, repeating proponent or habitual behaviors when they are no longer applicable (Schubert et al., 2015). The concept of fluid intelligence encompasses the general capacity for reasoning, adaptability to the world, pattern recognition, and problem-solving without particular prior knowledge or experience are all encapsulated in the concept of fluid intelligence (Colliflower, 2013). Fluid intelligence is associated to with attention and capacity in memory. The short-term maintenance and manipulation of mental information is referred to as working memory (Cochrane et al., 2019).

Working memory is a brief storing system that transmits the available information to core mental functions. WM (Working memory) is the capacity to manipulate and keep information for short periods of time. WM can be distinguished from (STM) short-term memory. According to the models of WM, it encompasses both processing the information and storing the information, while STM is purely responsible for storing information within certain informational spheres. Working memory serves as on-line available information system. This information is being used in problem solving, language comprehension and planning. According to Baddeley (2010), this system also supports the executive control process and responsible for the active preservation of information.

Working memory is one of the executive cognitive functions that controls how well various cognitive tasks are completed. The multi-construct of working memory is used to temporarily handle information that may have been acquired recently or retrieved from long-term memory. Working memory (WM) is a type of active memory system that has been the center of numerous researches and discussions over the last decades (Baddeley, 2010). Speed is emphasized by some researchers as a more accurate indicator of how well the brain processes information. (Jensen et al., 2007). Processing speed refers to the capacity to answer to the verbal and visual information. This information system also decides about the available information. Processing speed also discriminate, identify and integrate the available information. Parental education, a nonmaterial indicator can impact on a broad range of physiological, cognitive and social functions (Pinquart and Sorensen, 2000).

Hackman et al. (2015) explored that at kindergarten entry, children of highly educated mothers showed better working memory-Updating capacity. Likewise, researcher also found that the connotation between executive function and maternal education persisted without widening or narrowing across early and middle childhood (Hackman et al. 2015).

Usually educated parents unintentionally involve their children in the activities that aimed at improving WM-Updating skills. It is evident from the researches that educated mothers show contingent behavior (Carr & Pike, 2012) which may become the reason of some executive cognitive functions (Hughes & Ensor, 2009) highly educated mothers answer more contingently (Hoff, 2003), which has the potential to affect a variety of executive functions (Fay Stammbach et al., 2014).

For instance, Susperreguy et al., (2020) reported that more educated mothers involve more frequently with their children in literacy and numeracy activities in home. Similarly, Tracey and Young, (2003) mentioned that highly educated mothers usually remained involve with their children in number-related conversations and ask more questions (including high-level queries) that may can tap on working memory resources.

Empirical research has started focusing on the impact of parental education on core cognitive functions like fluid intelligence, attention, short term memory, long term memory, processing speed and creativity but still little is known about the independent influence of mother's educational level on the central executive cognitive function. The current study was aimed to investigate the influence of mother's education on working memory, short-term memory, processing speed, and fluid intelligence.

Study Objectives

- To assess working memory capacity, processing speed and fluid intelligence of school students.
- To measure the mutual relationship between working memory, processing speed and fluid intelligence of school students.
- To investigate the impact of mother's educational level on working memory, short term memory, processing speed and fluid intelligence.

Hypotheses

- There is likely to be a significant positive relationship among information processing speed, working memory capacity, short term memory and fluid intelligence of school students.
- Mother's education likely to have an impact on the working memory, processing speed, short term memory and fluid intelligence od school students.

Methodology

Research Design

Correlational and comparative research design was used for the Study.

Sampling strategy and sample

The population of this study was school students, with age range 15 -16 years, studying in matriculation stream of education (science group) and Cambridge (O level) stream of education (science group). The study's sample size was 300 participants and according to Kline (2015) declares that for multi-group modeling, the rule of thumb for sample selection is 100 cases/observations per group. 100 (boys=50, girls=50) students from 9^{th} and 10^{th} class (science group), studying under Urdu medium of instruction in private schools, 100 (boys=50, girls=50) students from 9^{th} and 10^{th} class (science group), studying under English medium of instruction in private schools and 100 (boys=50, girls=50) students from O Level (science group) were selected randomly from private schools by using two stage cluster sampling technique. Total sample was comprised of 300 students (boys=150, girls=150).

Assessment Measures

Demographic Information sheet was used to collect information about sample's personal, educational and familial characteristics. WISC-IV (Wechsler, 2003) includes four indexes, for present study two indexes, processing speed index and working memory index, and sub test digit span were used for the assessment of the processing speed and working memory capacity and short-term memory of the school students. And the Raven's Standard Progressive Matrices was used to assess the fluid intelligence of the students.

Procedure

Sample was selected from private schools at Faisalabad. Respective school authorities were approached with permission letters. They were communicated about the objectives of the present study and explained significance of the present study in Pakistani scenario and they assured that follow-up sessions would be arranged for the research participants in case of need. They were also promised about the study's goals and its significance in Pakistan. Sample of the study was taken randomly from different private schools through two stage cluster sampling technique. Informed consent was taken from the research participants before data collection. Detailed briefing was given to them about the purpose and utilization of the data. Data was collected individually, practically and face to face from the students. After taking the informed consent and giving briefing to the students, a biodata form, containing the information about the demographic variables like gender, age, stream of education, mode of instruction, mother and father education, socio economic status, etc. was given to the participants. Raven progressive Matrices, Working Memory Index, Processing Speed Index and digit span were administered to assess the student's fluid intelligence, working memory capacity, processing speed and short-term memory respectively. After the collection of data, raw data was arranged and analyzed through SPSS version 27.

Results

Following steps were taken to arrange and analyze the data. Descriptive statistics (means, standard deviations, frequencies, and percentages) were initially used to determine the sample's demographics. Reliability coefficient, mean, standard deviation and skewness were computed for all study variables. Pearson Product Moment Correlation was used to find the relationship between all study variables. One Way *MANOVA* was used to assess the impact of mother's education levels on fluid intelligence, working memory capacity, short term memory and processing speed.

According to descriptive analysis of demographic data, a total of 300 participants with 150 female (50%) and 150 male (50%) were included in the study. The age of the participants was ranged between 15 to 16 years. Father's education level of 44 % participants was graduation, 5 % was post-graduation, 26% was matriculation, 20 % was Intermediate and of 5% was below matric, whereas mother's educational level of 8 % participants was post-graduation, 47% was graduation, 25 % was intermediate,15% was matriculation and of 4% was below matric. 55% participants were living in nuclear family system, and 45 % were living in joint family system.

Table 1: *Descriptive analysis of Fluid Intelligence, digit span, letter number sequencing, arithmetic, coding, symbol search, cancellation, processing speed, cognitive control and working memory. (N=300)*

Variables	***M***	***SD***	***α***	***Range***		***Skewness***		***Kurtosis***	
				Potential	***Actual***	***Statistic***	***Std. Error***	***Statistic***	***Std. Error***
Fluid Intelligence	43.22	6.14	.80	30-58	0-60	-.138	.141	-.570	.281
Short Term Memory	18.93	3.76	.76	10-29	0-32	.212	.141	-.210	.281
Processing Speed	195.64	17.23	.84	144-236	0-314	-.238	.141	-.388	.281
Working Memory	63.15	6.86	.83	47-78	0-96	-.112	.141	-.511	.281

Table 1 represents the descriptive statistics of fluid intelligence, short term memory, processing speed and working memory. As reported by George & Mallery, 2010; Gravetter & Wallnau, 2014, the standard limit of skewness and kurtosis is between -2 and +2 standard limit for normal data spread. Table 1 shows that all the scales used to assess study variables have skewness and kurtosis within acceptable limits (±2); which indicates that data on these variables were normally distributed.

This table also represents the mean, standard deviation and Cronbach's alpha (reliability) for each study variable. Fluid intelligence of the students has Cronbach alpha .80, the mean and standard deviation were 43.22 and 6.14. Mean, standard deviation and Cronbach's alpha for short term memory of the students were 18.93, 3.76 and .76 respectively. Mean of Scores of the students on study variable processing speed was 195.64, standard deviation 17.16 and reliability .84. Working memory of the sample has Cronbach alpha .83, the mean and standard deviation were 63.15 and 6.86. The above table depicts that all values of skewness and kurtosis lie within the standard range which indicating that the scores of the sample on all study variables were normally distributed

Table 2: *Correlations among Study Variables: Fluid Intelligence, Processing Speed, Working Memory and short-term memory in the school students (n=300).*

Variables	*M*	*SD*	1	2	3	4
1.Fluid Intelligence	43.22	6.14	_			
2.Processing Speed	195.64	17.16	.616***	__		
3.Working Memory	63.15	6.86	.799***	.609***	_	
3.Short Term Memory	18.93	3.76	.714***	.521**	.883***	__

***P* < .01, ***P < .001

Table 2 reveals the association among study variables: Fluid Intelligence, processing speed, working memory in school students. Results indicated significant and positive association of fluid intelligence with working memory *r*= .799, *p**** < .001, with processing speed *r*= .616, *p**** < .001, and short-term memory *r*= .714, *p**** < .001. Working memory was positively and significantly correlated with processing speed *r*=.703, p*** < .001 and short-term memory *r*= .883, *p**** < .001, Results also indicated that processing speed was significantly associated with short-term memory *r*= .521, *p*** < .01

Table 3: *MANOVA Study Variables: Fluid Intelligence, Processing Speed, short term memory and Working Memory in the school students (n=300).*

Variable		Value	F	p	Partial eta seq	Power
Mother education	Pillai Trace	418	8.56	< .001	,104	1.00
	Wilks Lambda	.598	10.214	< .001	.120	1.00
	Hotellings Trace	.647	11.763	< .001	.139	1.00

****P* < .001

Pearson correlation was performed, before conducting the MANOVA, between all of the dependent variables to test the assumption of MANOVA that the moderate relationship should be present between all dependent variables (Meyer, Gampst, & Guarino, 2006). Table 1 showed that all the dependent variables were meaningfully correlated and indicated the suitability of data for MANOVA. Furthermore, checking out the Box's M test we find that the test was non-significant (which means that there were non-significant differences among the groups in the covariance matrices). The Box's M value was 60.74 with a p value of .06, which was interpreted as non-significant Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA.

To test the hypothesis that there would be one or more mean differences found between mother's education levels (below matric, matric, intermediate, graduate, post-graduation) and dependent variables (fluid intelligence, working memory, processing speed, short term memory) test scores, one-way MANOVA was demonstrated. Table indicated highly significant MANOVA effect, Wilks Lambda =.598, *F* (16,893) 10.214, p <.001. Partial eta square, the multivariate effect size was .120, which implies that 12.0% of the variance was accounted for canonically derived dependent variables by mother's educational level.

Table 4: *Mean, Standard Deviation and series of follow up ANOVA comparing Mother's Education Levels (Below Matric, Matric, Intermediate, Graduation, Post-Graduation) for Fluid Intelligence, Working Memory, Processing Speed, Sort Term Memory (N=300).*

	Below Matric		Matric		Intermediate		Graduation		Post-Graduation			
Variables	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F (4, 295)**	**η^2**
Fluid Intelligence	35.17	3.56	38.9	5.31	41.09	5.55	45.2	4.95	50.00	4.32	35.60***	.33
Working Memory	53.67	3.98	57.5	6.00	60.76	6.47	65.3	5.84	70.00	4.39	34.49***	.32

Processing Speed	172.1	9.68	185	18.6	190.8	15.1	200	14.4	210.1	11.9	24.35***	.25
Short-Term Memory	14.00	2.59	15.8	2.71	18.32	3.69	20.0	3.31	22.92	2.99	30.47***	.29

****P*< .001

Series of follow up ANOVA was used to compare mother's education levels for the mean scores of school students on fluid intelligence, working memory processing speed and short-term memory.

The assumption of homogeneity of variance was tested for all four dependent variables, before conducting a series of follow-up ANOVAS. For the variances of the dependent variables to be equal across all levels of the independent variable, Levene's test was used. The homogeneity of variance assumption was considered satisfied, four Levene's tests were statistically in significant ($p > .05$), suggesting that the variances associated with the four dependent variables were homogenous. suggesting that the ANOVA would be robust in this case (Howell, 2009). A series of one-way ANOVAs on each of the four dependent variables was conducted as a follow-up test to the MANOVA.

According to results, highly significant difference was found between the levels of mother's education on the mean score of students on fluid intelligence $F\ (4,295) = 35.09$

$p = .001$ with large effect size $\eta^2 = .33$. Results also indicated significant mean differences between the mother's educational levels of students on their mean scores of working memory $F\ (4, 295) = 34.49$, $p = .001$ with large effect size $\eta^2 = .32$, processing speed $F\ (4, 295) = 24.35$, p*** =.001 with large effect size $\eta^2 = .25$. short-term memory $F\ (4, 295) = 24.35$, $p = .001$ with large effect size $\eta^2 = .29$.

Table 5: *Pairwise comparison of ANOVA comparing Mother's Education Levels (N=300)*

					95%CI	
Variables	**Pairs**		***MD***	***p***	***LB***	***UB***
Fluid Intelligence	Post-Graduation	Graduation	4.789	.001	2.62	6.95
	Post-Graduation	Intermediate	8.91	.001	6.60	11.21
	Post-Graduation	Matric	11.04	.001	8.56	13.52
	Post-Graduation	Below Matric	14.83	.001	11.33	18.34
	Graduation	Intermediate	4.12	.001	2.69	5.54
	Graduation	Matric	6.26	.001	4.56	7.95
	Graduation	Below Matric	10.05	.001	7.04	13.05
	Intermediate	Matric	2.17	.025	.27	4.01
	Intermediate	Below Matric	5.93	.001	2.82	9.03
	Matric	Below Matric	3.79	.022	.55	7.03
Working Memory	Post-Graduation	Graduation	4.75	.001	2.25	7.26
	Post-Graduation	Intermediate	9.24	.001	6.57	11.91
	Post-Graduation	Matric	12.50	.001	9.63	15.37
	Post-Graduation	Below Matric	16.33	.001	12.28	20.39
	Graduation	Intermediate	4.49	.001	2.84	6.13
	Graduation	Matric	7.75	.001	5.79	9.71
	Graduation	Below Matric	11.58	.001	8.11	15.05
	Intermediate	Matric	3.260	.003	1.10	5.42
	Intermediate	Below Matric	7.093	.001	3.50	10.68
	Matric	Below Matric	3.83	.045	.09	7.58
Processing Speed	Post-Graduation	Graduation	9.75	.003	3.35	16.15
	Post-Graduation	Intermediate	19.31	.001	12.5	26.12
	Post-Graduation	Matric	25.10	.001	17.77	32.43
	Post-Graduation	Below Matric	37.83	.001	27.47	48.19
	Graduation	Intermediate	9.56	.001	5.35	13.77

	Graduation	Matric	15.35	.001	10.35	20.36
	Graduation	Below Matric	28.08	.001	19.22	36.95
	Intermediate	Matric	5.79	.04	.27	11.32
	Intermediate	Below Matric	18.52	.001	9.35	27.69
	Matric	Below Matric	4.86	.009	3.17	22.29
Short term Memory	Post-Graduation	Graduation	2.91	.001	1.51	4.30
	Post-Graduation	Intermediate	4.60	.001	3.11	6.09
	Post-Graduation	Matric	7.03	.001	5.43	8.63
	Post-Graduation	Below Matric	8.92	.001	6.65	11.19
	Graduation	Intermediate	1.69	.001	.77	2.61
	Graduation	Matric	4.12	.001	3.03	5.22
	Graduation	Below Matric	6.01	.001	4.08	7.95
	Intermediate	Matric	2.43	.001	1.22	3.64
	Intermediate	Below Matric	4.32	.001	2.31	6.33
	Matric	Below Matric	1.89	.076	-.2	3.98

*p**< .05. *p***< .01. *p****< .001.

Finally, a series of post-hoc analyses (Fisher's LSD) were performed to examine individual mean difference companions across all five levels of education and all four dependent variables. The results revealed that all post-hoc mean comparisons were statistically significant ($p < .05$). In all cases, the trend of the effect was linear.

Discussion

Study was aimed to assess that how maternal education affected all the study working memory capacity, short-term memory, processing speed, and fluid intelligence, of school students. Working memory, short-term memory, processing speed, and fluid intelligence were all thought to be associated with one another. Besides, it was also expected that education level of mother would impact fluid intelligence, working memory, short term memory and processing speed.

Primarily it was hypothesized that fluid intelligence, working memory, short term memory and processing speed would be associated with one another. Pearson product moment correlations (two-tailed) were used to investigate the association between processing speed, working memory, short term memory, and fluid intelligence. The study's statistical analysis revealed that working memory and processing speed were significantly and positively correlated with fluid intelligence. Working memory was also positively and significantly associated with processing speed. Short term memory was also positively and significantly associated with fluid intelligence, processing speed and working memory.

Conway & Kovacs (2013) hypothesized that working memory and fluid intelligence (Gf) were positively correlated, which is consistent with the current findings of this study. A meta-analysis of 86 such researches that assessed relationship of intelligence and working memory was completed by Ackerman, Beier, and Boyle (2005). Working memory and intelligence were found to be significantly relation in the studies that were included in this meta-analysis. Working memory and intelligence shared between 50 and 70 percent of their common variance, according to a number of additional studies (Kane et al., 2005; Oberauer et al., 2005). In a similar vein, the intercorrelation between working memory, processing speed, and fluid intelligence was reported by Fry & Hale (2000).

Some early longitudinal studies have successfully addressed the connection between fluid intelligence, working memory, and processing speed (Oberauer & Eichenberger, 2013). According to some evidences, processing speed is the primary factor that determines individual intelligence differences (Namazi & Thordardottir, 2010).

Findings of the present study were also supported by Wongupparaj, Kumari, & Morris (2015), who examined the relationship between general intelligence in 110 healthy participants and the various functions of working memory, particularly the short-term storage components (phonological loop and visuospatial sketchpad) and central executive functions (shifting, inhibition, and updating). The major findings support a multifaceted model of the central executive and demonstrate that updating, inhibition, and short-term memory differentially correlate with general intelligence, including both fluid and crystallized intelligence. These findings imply that working memory's processing and storing capacities influence its relationship to general intelligence.

Present research hypothesized that level of mother's education would impact fluid intelligence, working memory, processing speed and short-term memory. Results of the present study supported this hypothesis. Results indicated that education level of mother impacted all the study variables more specifically fluid intelligence and working memory. A mother's level of education is important for school students. Children of mothers with a college education are more likely to participate and stimulate their cognitive development.

Hackman et al. (2015) found that kids with educated mothers showed better working memory- Updating capacity. According to Susperreguy et al. (2020) for instance, educated mothers frequently involve their children in home literacy and numeracy activities. Similarly, Hornburg et al. (2018) found that mothers with more education have more frequent conversations with their children about numbers. Similarly, Tracey and Young (2002) suggested that educated mothers engage in joint reading with their children by asking more questions, including high-level ones, which may utilize working memory resources.

According to recent researches more educated mothers intentionally engaged their children in activities that explicitly contributed to the development of WM-Updating skills, these are instances in mother-child interactions where WM resources can be utilized. Singing songs or engaging the child in games or tasks with multiple steps, for instance, can use up the child's WM resources. In addition, we discovered that only mother education influenced children's cognitive development rates (Muez, Bull, & Lee, 2022).

Conclusion

Present study provides in-depth information regarding the impact of the educational level of the mothers on fluid intelligence, working memory, processing speed and short-term memory. An educated mother can better support her children to be well adjusted in all fields. From the present study it is evident that and educated mothers can become the source of knowledge, guidance for the development of core cognitive areas which are directly related to educational performance and even for the better adjustment in the life. She can become the source of strength when she takes the responsibility to teach and solve the educational problem of her children. Educated mothers involve more frequently with their children in literacy and numeracy activities in home. Educated mothers have the practical knowledge and skills which become the source of improved processing speed, working memory, short term memory and ultimately fluid intelligence which is closely related to learning and educational attainment and the ability to reason, design & deal with problems. By observational leaning children of an educated mother can learn many skills and confidence as non-formal education. Educated mother can brings a natural and lasting change in her children's reasoning and ability to achieve the targeted goals of life. Girls are mothers of future generations, so they should be educated to get nation with improved cognitive abilities.

Acknowledgments

None

Conflict of Interest

Authors declared no conflict of interest.

Funding Source

The authors received no funding to conduct this study.

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