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PARENTAL EDUCATION AS A FACTOR CORRELATED TO COGNITIVE PERFORMANCE IN OFFSPRING

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Abstract. Background: *The purpose of the study was to investigate the correlation between the results of 4 cognitive tests and years of parental education and to analyze their impact on cognitive performance in mentally healthy subjects.* **Subjects and Methods:** *The sample consisted of 72 mentally healthy subjects (25 men, 47 women) assessed by 4 cognitive tests – the Trail Making Test A (TMT-A), the Trail Making Test B (TMT-B), Digit Symbol Test (DST) and Verbal Fluency Test (VFT). Results were analyzed with descriptive statistics, Pearson correlation analysis and the partial correlation method to control the influence of one factor on the correlation between two variables.* **Results:** *More years of parental education were associated with higher cognitive results. All four tests showed that mother's years of education have stronger positive influence on the cognitive performance of the child than fathers's years of education. For mothers this positive influential correlation have reached statistical significance for two cognitive tests – TMT-A ($p < .000$) and TMT-B ($p < .007$) and for DST was close to reaching statistical significance ($p < .103$), while for fathers only TMT-A has showed a statistically significant correlation. These general patterns of tendencies of parental education as a factor correlated to cognitive performance in offspring are retained even after controlling for subject's age or years of education, which independently have strong correlations with the results of the 4 cognitive tests.* **Conclusions:** *Mother's years of education affect cognitive functions of the offspring much more than father's years of education.*

Key words: *cognition; education, parental years of education*

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INTRODUCTION

Cognition is a broad concept that includes various functions of the human brain – attention, memory with all its subcategories, learning ability, executive functions, motor functions, intelligence. When talking about hemispheric asymmetry and its provision, scientists are almost unanimous about the leading role of the right hemisphere. It is known that general sustained attention (vigilance) provides the ability to maintain adequate behavioral activity for a long time and guide cognitive activity. In contrast, selective attention provides the ability to maintain a set of behavioral acts or cognitive processes despite the presence of distracting or competing stimuli. Some authors advocate the thesis that the left hemisphere is more specialized in selective attention processes than the right [1]. The main structures involved in the cognition process are PFC, anterior cingulate cortex and parietal cortex hyppocampus and basal ganglia.

A wide range of factors has been associated to neurocognition like age and education. The inevitable cerebrovascular changes of aging affect cognitive function and motor abilities. Factors like the parental age and parental years of education are some of the most consistently reported to influence the functional and cognitive outcome of the offspring.

Some authors find that parental cognitive abilities influence offspring performance on measures of cognition [2]. Other authors report that mothers' and fathers' education are protective of cognitive impairment in offspring [3]. Some studies clearly show that parental education, in addition to the education of the subject can counteract cognitive decline in later life [4, 5, 6, 7].

In the current article we present our investigation on the influence of the age and education of the studied subjects as well as the parental age at subject's birth and parental years of education on cognition. We also analyzed how the correlation between cognitive performance of the subject and years of parental education change when not controlling and when controlling for confounding factors such as the age and years of education of the subject.

SUBJECTS AND METHODS

Subjects

The study was conducted at UMHAT "Aleksadrovska" in Sofia, in the Clinic of Psychiatry on mentally healthy subjects – medical staff and medical students. The sample included 72 subjects (25 men, 47 women) with a mean age of 31.26 years (SD = 13.17, range 18-79), men – 29.40 years (SD = 11.00, range 18-61) and women – 32.25 years (SD = 14.20, range 23-79). The mean years of education of the sample was 12.11 years (SD = 2.15, range 8-16).

Using SPSS, we computed the correlation coefficients between these 10 variables, excluding any one subject with a missing data for even one of the ten variables. This SPSS algorithm results in different numbers of subjects for any one particular computed correlation coefficient.

The absence of mental illness was defined as no major disorder according to DSM-V [8], based on an interview by the psychiatrist (K.A.) and collateral information from friends and relatives if needed. In order to enhance the homogeneity of the group, potential subjects were excluded if they had a history of drug or alcohol abuse, identifiable neurological disorder (seizure disorder, head injury, multiple sclerosis, etc.), any signs of intellectual disability or somatic disorder with neurological components.

To avoid confounding due to genetic ancestry, patients with ethnic and racial differences were excluded from the study and only patients of Bulgarian origin were included; individuals were excluded if their parental or grandparental ethnic group was other than Bulgarian.

The study was approved by the local Ethics Committee of Medical University of Sofia. All subjects provided written informed consent prior to participation.

Instruments

Four cognitive tests were used to study cognitive functions in healthy subjects.

In Trail Making Test A, B (TMT-A, B) [9] the examined person has to consecutively connect the numbers up to 25, which are written in a jumbled manner. In part B, after each number, the corresponding letter of the alphabet must be connected. If a mistake is made, the examined person must correct it before proceeding further. For both tasks, the time needed for the subject to complete the task was estimated in seconds.

The Digit Symbol Test (DST) [10] is a test in which the subject must write a sign under a corresponding symbol for 90 seconds, using a symbol key associated with the digits. Correct answers are counted.

In the Verbal Fluency Test (VFT), the subject must reproduce as many words as possible from a certain category in 60 seconds. The number of correct answers is counted.

All assessments were performed by the same examiner (K.A.).

Statistical Analysis

The data were analyzed using SPSS 25.0 descriptive statistics, Pearson correlation analysis, and the partial correlation method to control the influence of one factor on the correlation between two variables.

Statistical significance was defined as $p < 0.05$; two-tailed.

RESULTS

The descrptive statistics of the applied cognitive tests were as follows: Trail Making Test A with mean score 25.00 sec (SD = 6.887, Min-13–Max-48, Range – 35); Trail Making Test B with mean score 49.46 sec (SD = 15.636, Min-25–Max-100, Range -75); Digit Symbol Test with mean score 56.63 (SD = 9.055, Min-35–Max-77, Range – 42); Verbal Fluency Test with mean score 24.96 (SD = 5.952, Min-14–Max-38, Range – 24).

Table 1 shows the correlation matrix between 72 subjects (25 men, 47 women) with 9 studied variables – four cognitive tests, age of the subject, parental (mother and father) education and parental (mother and father), age at birth of the studied person. In statistics the magnitude of the correlation coefficients may extend from correlation coefficient = -1 (absolute negative correlation – inverse), passing through correlation coefficient = 0 (no correlation at all) to correlation coefficient = 1 (absolute positive correlation).

When interpreting the results, we should consider the fact that for Trail Making Test A and B better cognitive performance implies lower values. Thus, the shorter the time in seconds is, the better the cognitive performance of the studied subject is. On the contrary, when performing Digit symbol test and Verbal fluency tests, higher values indicate better cognitive performance of the subject. That is why, although some of the correlations between the tests and studied subject' cognitive performance is negative, they show actually a favorable influence on cognition.

Logically as the age of the examined subjects advanced, the cognitive results decreased and it was statistically significant for (Table 1) – Trail Making Test-A (Pearson Correlation = 443, p < .001), Trail Making Test – B (Pearson Correlation = .298, p < .035) – the time in seconds needed for the subject to complete the task incresed and Digit Symbol Test (Pearson Correlation = .-.408, p< .004) – correct answers decreased. Only Verbal Fluency Test didn't have statistically significant correlation with the age of the examined subjects.

In our sample, no statistically significant correlation has been found between any of the 4 cognitive tests and maternal or paternal age at subject's birth (Table 1).

Two of the four test – Trail Making Test A (Pearson Correlation = -.489; p < .000) and Trail Making Test B (Pearson Correlation = -.378; p < .007) showed statistically significant negative correlation with mother's years of education. In this case the negative correlation actually indicates a favorable correlation between years of education and cognitive performance. That means, the more years of education the mother

Table 1. Pearson correlation matrix between 4 cognitive test, age and education of the studied subjects' parents age at subject birth and parental education

		TMT-A	TMT-B	DST	VFT	Age	Age of father at subject's birth	Age of mother when at subject's birth	Years of education of father	Years of education of mother
TMT-A	Pearson Corr									
	Sig. (2-tailed)									
	N									
TMT-B	Pearson Corr	.479**								
	Sig. (2-tailed)	.000								
	N	50								
DST	Pearson Corr	-.409**	-.556**							
	Sig. (2-tailed)	.004	.000							
	N	49	49							
VFT	Pearson Corr	-.195	-.310*	.227						
	Sig. (2-tailed)	.179	.030	.117						
	N	49	49	49						
Age	Pearson Corr	.443**	.298*	-.408**	.045					
	Sig. (2-tailed)	.001	.035	.004	.755					
	N	50	50	49	50					
Age of father at subject's birth	Pearson Corr	-.236	.120	-.039	.257	-.166				
	Sig. (2-tailed)	.110	.423	.798	.081	.175				
	N	47	47	46	47	68				
Age of mother at subject's birth	Pearson Corr	-.252	.058	.006	.135	-.351**	.792**			
	Sig. (2-tailed)	.081	.693	.970	.355	.003	.000			
	N	49	49	48	49	70	68			
Years of education of father	Pearson Corr	-.380**	-.189	.191	.050	-.510**	.109	.438**		
	Sig. (2-tailed)	.006	.188	.188	.728	.000	.375	.000		
	N	50	50	49	50	72	68	70		
Years of education of mother	Pearson Corr	-.489**	-.378**	.236	.138	-.616**	.260*	.542**	.768**	
	Sig. (2-tailed)	.000	.007	.103	.339	.000	.032	.000	.000	
	N	50	50	49	50	72	68	70	72	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

has, the better the subject's cognitive performance is. Digit symbol test and Verbal fluency test did not show statistically significant correlation with mother's years of education.

In this regard the analysis of the correlation of father's years of education and the cognitive performance of the studied subject showed only one statistically significant negative correlation for Trail Making Test – A (Pearson Correlation = -.380; p < .006).

Parental education and studied subject's cognitive function and age

The age of the subjects is a factor with an undeniable influence on the cognitive results of the studied subjects and it is necessary to be controlled when assessing our subjects' cognitive functions. We examined the correlation between the cognitive performance of the 4 tests and mother's years of education, while controlling for subjects' age.

When controlling for the subject's age, the negative Pearson correlation coefficients between cognitive performance of TMT-A and TMT-B and mother's years of education decreased, but the correlation still remained statistically significant for TMT-A and almost reached statistical significance for TMT-B (Table 2). This clearly shows the importance of the subject's age as a factor to be controlled.

DST and VFT did not show statistically significant correlations between the cognitive performance of the studied subjects and mother's years of education both when subject's age was not controlled and when controlled, most probably due to the specific features of the tests and eventually to the relatively small sample size.

When we controlled for the subject's age as a confounding variable, the only statistically significant correlation between the cognitive performance of the studied subjects and the father's years of education lost its statistical significance.

As a whole, our data showed, that the obligatory controlling of subject' age while studying the correlation between the cognitive performance of the studied subjects and parent's years of education, confirms

Table 2. Comparison of the correlations of the 4 cognitive tests and years of mother's and father's education with and without controlling the age of the examined subjects

		Correlation with years of education of mother with uncontrolled subject's age	Correlation with years of education of mother with controlled subject's age
TMT- A	Pearson Corr	-.489**	-.304
	Sig. (2-tailed)	.000	.034
	N	50	47
TMT- B	Pearson Corr	-.378**	-.257
	Sig. (2-tailed)	.007	.074
	N	50	47
Digit_symbol test	Pearson Corr	.236	-.025
	Sig. (2-tailed)	.103	.867
	N	49	46
Verbal fluency test	Pearson Corr	.138	.213
	Sig. (2-tailed)	.339	.143
	N	50	47
		Correlation with years of education of father with uncontrolled subject's age	Correlation with years of education of father with controlled Subject's age
TMT-A	Pearson Corr	-.380**	-.184
	Sig. (2-tailed)	.006	.205
	N	50	47
TMT-B	Pearson Corr	-.189	-.033
	Sig. (2-tailed)	.188	.821
	N	50	47
Digit symbol test	Pearson Corr	.191	-.040
	Sig. (2-tailed)	.188	.785
	N	49	46
Verbal fluency test	Pearson Corr	.050	.087
	Sig. (2-tailed)	.728	.551
	N	50	47

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed) the greater importance of the mother's education compared to the father's education in the offspring's cognitive performance.

Parental education and studied subject's cognitive function and education

The education is also a factor affecting the performance on cognitive tests, so it should be controlled in statistical analyses. When controlling for the subject's years of education, the negative Pearson correlation coefficients between cognitive performance of TMT-A and TMT-B and mother's years of education decrease, but they still remain statistically significant (Table 3), again demonstrating the favorable influence of more years of education of the mother on the cognitive performance of the subject. This shows again the importance of the subject's education as a factor to be controlled.

As already noted DST-test and VFT-test did not show statistically significant correlation between the cognitive performance of the studied subjects and mother's years of education. This trend remains the same when the factor subject's education is controlled.

In regard to father's education the only statistically significant correlation between the cognitive performance for TMT-A and the father's years of education retains its statistical significance when controlling for the subject's years of education.

It is evident from our data that in general, mother's years of education play a much more important positive role than father's years of education in the cognitive performance of their offspring.

DISCUSSION

Cognitive skills like executive functioning, working memory, and verbal IQ are critical for educational success. As some researches point the educational attainment has been hypothesized to influence brain health through the creation of compensatory neural circuits, known as "cognitive reserve". This increase the capacity of the brain to resist to damages from vascular and inflammatory brain insults due to aging [11]. Through education the subject also acquires the skills and resources needed to maximize his poten-

Table 3. Comparison of the correlations of the 4 cognitive tests and years of mother's and father's education with and without controlling the subject's years of education

		Correlation with Years of education of mother with Uncontrolled subject's years of education	Correlation with Years of education of mother with Controlled subject's years of education
TMT-A	Pearson Corr	-.489**	-.461
	Sig. (2-tailed)	.000	.001
	N	50	47
TMT-B	Pearson Corr	-.378**	-.283
	Sig. (2-tailed)	.007	.049
	N	50	47
Digit symbol test	Pearson Corr	.236	.118
	Sig. (2-tailed)	.103	.423
	N	49	46
Verbal fluency test	Pearson Corr	.138	.202
	Sig. (2-tailed)	.339	.163
	N	50	47
		Correlation with Years of education of father with Uncontrolled subject's years of education	Correlation with Years of education of father with Controlled subject's years of education
TMT- A	Pearson Corr	-.380**	-.352
	Sig. (2-tailed)	.006	.013
	N	50	47
TMT- B	Pearson Corr	-.189	-.109
	Sig. (2-tailed)	.188	.456
	N	50	47
Digit_symbol test	Pearson Corr	.191	-.111
	Sig. (2-tailed)	.188	.451
	N	49	46
Verbal fluency test	Pearson Corr	.050	.086
	Sig. (2-tailed)	.728	.557
	N	50	47

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed) tial for a longer, healthier life via the embracing of healthier behaviors. There is evidence that education is one of the most effective resources, which delay the onset of cognitive impairment in later life [12] and years involved in formal learning is one of the main components of the cognitive reserve. Authors point that education plays a critical role as individuals with more years of schooling are less likely to be cognitively impaired than those with fewer years of schooling [13]. The concept of cognitive stimulation, the so called "cognitive reserve" during early life, which leads to physical, neurological, and chemical changes in the brain itself is undisputed [12, 14].

The data from our sample confirms the well-known fact that the advanced age deteriorates cognitive performance. The lack of statistical significance between the age of the subject and the results of the Verbal fluency test is due to the presumption that the semantic mastery of the language with the advancement of the years leads rather to its enrichment.

Our data is consistent with previous findings revealing the protective role of mother's and father's years of education on cognitive impairment in adults (Greenfield & Moorman, 2018) [15] as well as other contexts [16, 17, 18]. Together with subject's education, parental years of education can prevent cognitive decline in later life [16, 19, 20], which is believed to be an indirect way of shaping children's cognitive health [12, 14]. The condition surroundings in early childhood health are closely linked to adulthood health and can be shaped by parental education [12]. For example, educated parents are more likely to maintain better early childhood health through childhood nutrition or protection of exposure to diseases [22]. The hypothesis of "cognitive reserve" emphasizes that the conditions in early childhood play a major role impacting brain's ability to function efficiently and effectively [13, 14].

An interesting finding in our research is the fact that mother's years of education play greater role in cognitive performance of the subject than father's years of education. An explanation of this is that linguistic functions in children arise and are strengthened through maternal influence – and only then do they become subject to other systems of social influence and learning. From an evolutionary perspective, child socialization involves training in language skills (unthinkable outside of human society), and the mother's role in this process (and for overall child development) has long been recognized and comprehensively discussed in psychology textbooks [23, 24, 25, 26]. The almost symbiotic mother-child bond is of particular importance for the child's acquisition of the language – in all its dimensions – and it is not an accident the common term "mother tongue".

CONCLUSION

The development of the brain is most intensive during infancy, but this process continues well into childhood and adolescence. Schooling and higher education increase immensely brain efficiency, which protects the individual from cognitive impairment in later life. Mother's years of education play much more significant role than father's years of education in the cognitive development of the offspring not only because of mother's much more prominent role in child language development, but also because of her much more substantial role in the offspring's skills training and child raising on the whole.

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