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**LONGITUDINAL EXAMINATION OF PREMATURELY  
BORN CHILDREN'S MENTAL DEVELOPMENT AND  
ACADEMIC ACHIEVEMENT**

The notion of premature infant was introduced by Ylppö, Finnish pediatrician in 1919, and it refers to infants weighing less than 2500g at birth. Ylppö's definition today needs some correction. The WHO suggests that newborns can be divided into three major groups: the groups of premature, mature and postmature infants.

A premature infant is an infant born before 37 weeks of gestation. Within the group of premature infants we can distinguish the category of immature infants, who are born before 27 weeks of gestation. Mature infants are born at 37- 41 completed weeks of gestation.

The definition of premature infants above does not correspond to the old nomenclature which defines premature infants as babies weighing less than 2500g at birth. It is better to call these babies low birth-weight infants. Though the 2500g as a weight limit is an important statistic variable (Véghelyi 1979).

Another practical reason to use the notion of low birth-weight as suggested by the WHO is that only two thirds of premature infants are real premature babies who are born before 37 gestation weeks, while one third are low birth-weight infants whose birth-weight is substantially less than expected, given the infant's gestational age. They are full-term born infants but their birth-weight is less than 2500g. They are dysmature infants who had atrophy inside the uterus. Their intrauterine developmental quotient is less than 75. Their perinatal mortality rate is much greater than the average (Csiky 1981). The WHO suggests that premature infants are infants born before 37 weeks (259 days) of gestation. Depending on the demographic factors, 6-15 percent of pregnancies which are shorter than 37 weeks end in live-birth (Wolnuth 1986). According to the above mentioned facts, birth-weight and length of pregnancy should be examined in relation to each other.

**Research on the development of prematurely born children**

Research results on the development of prematurely born children are not unified. Some scientists do not find essential differences in the psychic and

mental development of prematurely born children and full-term born children. Others say that being a premature infant is a kind of predisposition to get into difficulties with development and there are residual symptoms of the nervous system to a greater extent.

Boda thinks (1981) that the factors that can cause preterm labor can cause disorders in the nervous system, too, and that is why perinatal complications occur more frequently. Preterm labor without complications itself does not result in problems in the nervous system or in the lower level of intelligence. Modern therapeutic methods reduce potential disorders of the nervous system which threaten premature infants to a great extent.

Michel Pavlovkin (1979) examined the problems of maturity in premature and dysmature infants. He proved that birth-weight affected the developmental quotient (he used the Brunet-Lezine test for the examination). Infants with very low birth-weight had lower quotients. Infants weighing less than 1750g had substantially lower quotients than other infants. Pavlovkin did not find any correlation between the parents' qualification level and the children's developmental quotient. Psychomotor development of premature infants approximated the average in the 12<sup>th</sup> month.

Hegedűs-Neményi (1976) also examined the psychomotor development of prematurely born children; 8.68 percent of the examined children weighed less than 2500g at birth. Many researchers came to the conclusion that children with low birth-weight usually develop slower than children with normal birth-weight. Considering psychomotor development, scores of infants with low birth-weight followed the same normal distribution curve as that of infants with normal birth-weight. The average of 418 infants' developmental quotient was significantly lower than the national average. However, low birth-weight cannot be seen as a disadvantage from the perspective of psychic development. (They used the Functional Development Test of Popper – Szondy – Hegedűs.)

The prognosis for infants weighing less than 1800g at birth is less favourable. In the group of infants with 1901-2190g birth-weight, the average of the developmental quotient decreased in a small compass only.

According to Emmi Pikler's data (1969), prematurely born children had a delay in motor development. Infants weighing 2001-2600g at birth showed an even delay (about 4-6 weeks), except for rolling over, which appeared 3 weeks later. Infants born with less than 2000g showed a delay of several weeks, 6 weeks on average; they started to walk 17 weeks later, more than a quarter of a year later than infants with normal birth-weight.

Wolmuth, G. and Fráter (1965) examined 193 prematurely born children at the age of 6 and 7. They diagnosed mild mental retardation or motor deficit in the case of 91 children and behavioral disorders in 68 children. 71

percent of the examined children had average intelligence quotients; but weak adaptive behaviour and attention deficit can influence good mental ability in a negative way.

Dann et al. studied the development of 100 prematurely born children with low birth-weight. They found that 62 percent of them had lower intelligence than the average.

Drillien examined 50 children born with less than 1300g at school age. 50 percent of them could attend a normal school, while 78 percent had some kind of behavioural disorder.

Many researchers agree that premature infants have disadvantages not only in their somatic development and functions of their sensory organs, but also in their neuro-motor functions and mostly in their psychosocial behaviour.

Wolmuth and Fráter (1973) diagnosed behavioural disorders and adaptation difficulties in 50 percent of prematurely born children. In the background of these problems there were hyperactivity, inhibited psychic tempo and emotional instability.

É. Kovács (1966) reports that 12 percent of 2800 children having behavioural disorders were prematurely born (132 children) and this percentage was the double of the frequency of prematurity in the control group (5.5 percent). 50 percent of prematurely born children were mentally retarded.

According to the studies, prematurity influences the child's psychic development, mainly if there are other pre- and perinatal complications.

Organic problems that decrease the child's tolerance towards the environment are often only temporal. There is often some kind of relation between these problems and the environmental effects. Environmental problems can result in further psycho-reactive symptoms, which can be more serious than somatic disorders.

Rajk, Csiky and Korányi (1979) examined children born with very low birth-weight, (less than 1251g) at the junior school age. Their somatic development was on the expected level given their chronological age. They had no substantial delay in the development of gross motor skills. Their fine motor skills, manual skills and motor coordination were underdeveloped. Examining the intelligence quotient they found psychic symptoms of mild cerebral dysfunction.

Csiky et al. (1981) studied children with very low birth-weight from the aspect of school maturity. These children differ in the factors of school immaturity from the group of children who are also immature to school but for different reasons. "We found that the psychic functions' development of children with very low birth-weight is substantially below expected given

their chronological age, not only from the aspect of intellectual abilities, but of other skills.” In this case we can speak about functional disorder and these symptoms can be treated with early, careful, proper therapy, and this disintegrated developmental progress can be harmonized.

According to the results of Falusné, prematurely born children do not differ from full-term born children in their general intelligence. Their verbal skills are normally developed. Their visual-motor and visual-perceptual skills are retarded. Their general mental levels show an uneven distribution. They typically have attention deficits, adaptation disorders and school immaturity at the age of 6. The symptoms of minimal impairment can be found also at the age of 9 and 16 (although they tend to improve).

Czeizel et al. (1978) studied the relations between birth-weight and length of gestation as one of the most essential factors of intrauterine development, and their impact on intellectual development.

Research on the normal population provided a new aspect in interpreting the relation between birth-weight and intellectual development. Douglas (1960) did not find any differences between the groups of children with various birth-weights, even in the group of prematurely born children. Donald (1964) examined many children with a birth-weight of less than 2000g, and he did not find any difference in their IQs either. The research group of Birmingham measured the performance of 41,534 children at the age of 11 on verbal tests. There was a linear relation between full-term born children’s birth-weight and their intelligence quotient. Children with a birth-weight of less than 2000g had the lowest intelligence quotient, while children with a birth-weight of more than 4500g had the highest. They also measured the intelligence quotient in one part of the examined children’s siblings. There was no significant relation between the children’s birth-weight and intelligence quotient within the family.

The research group of Birmingham did not find more than a 1.5 point difference in the IQ when there was 1500g deviation in the birth-weight. “The relation between birth-weight and intelligence can derive rather from the children’s social, economic situation which changes from family to family.”

This statement of the research group of Birmingham was supported by the results of research with twins (Record et al. 1970).

Kalmár et al. (1984) examined the influence of birth-weight on motor and mental development until the age of three and a half. The premature infants with more than 2000g birth-weight had similar performance as the control group. Premature infants with less than 2000g birth-weight showed a delay in some areas of development. They also studied the impact of parents’ education on the development. It did not influence the psycho-motor

development, but it did affect the Binet IQ. Supporting behaviour of the higher educated parents was very important with biologically immature children born prematurely.

Siegel (1985) examined the performance of prematurely born children (1500g) at the age of 7. They showed lower performance than the control group in the task requiring body-hand coordination and visual spatial-memory. The pre- and perinatal complications correlated rather with visual-spatial functions and attention, while social economic status (SES) and the mother's education correlated with verbal performance. Siegel suggested that the intelligence quotient as a global variable was not really informative; it was more worth examining each function with special tests. The intelligence quotient of most prematurely born children was in the normal zone, but function disorders causing learning disorders occurred more frequent in them than in full-term born children.

The results of two Hungarian longitudinal studies showed that the environmental process variable correlated with the intelligence quotient to a greater extent than with the SES (social economic status) in prematurely born children (Kalmár, Boronkai 1991), and it predicted more efficiently the academic achievement (Estefánné Varga, Kalmár 1986, 1989, 1994, 1996).

It is an important question how prematurity influences the performance on school maturity tests. Manual workers' children born prematurely had lower performance than full-term born children who come from the same social milieu and than the intellectuals' prematurely born children. 46 percent of children who were relieved of compulsory school attendance were prematurely born children.

Csiky et al. (1981) examined the school maturity of children with low birth-weight. According to their result there was no delay in the body measures. The development of psychic functions was disharmonic and disintegrated. Attention deficit, hyperactivity, psychic weariness, emotional instability occurred to a greater extent in the examined group.

Vargáné and Szabó (1979) studied factors which influence school maturity and immaturity in children in Budapest. In their research they studied prematurely born children's problem with school maturity, too. According to their results, there was a relation between birth-weight and the child's development. 22 percent of the children who were immature for school were born with less than 2500g, while only 8 percent of the children who were mature for school were born prematurely. Besides biological factors, the environmental and cultural factors and the family's child-rearing attitude are also very important in development. School immaturity has multicausal explanations. The factors of school maturity and immaturity

need to be analysed more thoroughly in order for children to start school without any problems.

Diagnosing school maturity or immaturity is very important in prematurely born children, because uneven development of functions could be a potential basis for learning disorders (P. Balogh, Estefánné 1989, 1991).

As it is widely known in the literature in Hungary and abroad, at the beginning of school, prematurely born children have more problems with the fulfilment of school requirements than their full-term born peers.

It has seemed to be natural for a long time that factors causing premature delivery (e.g.: pathological pregnancy) or effects on the nervous system as biological causes can have later consequences.

According to our knowledge and research (Kalmár 1993, Estefánné 1986) this relationship is not so explicit, because the biological risk factors can be modified or equalized by the environmental effects (family, school).

P. Balogh's different studies on the exploration and improvement of psychic functions that determine learning abilities reinforce the relation between early social economic status (SES) of the family and the development of perceptual motor functions (P. Balogh 1984, 1985, 1987, 1988). SES-handicapped children had a significant delay in their test results measuring body scheme, fine motoric skills and perceptual functions both in the control group and the experimental group (Oseretzky, Bender, Frostig, P. Balogh 1989, 1992; P. Balogh - Estefánné 1988, 1989).

The above mentioned relation suggests that biological risk factors and/or early mother-child relationship – the problems of the family milieu – are in the background of learning disorders which appear at school age. Though it is not well described yet how the latter influences this relation. Researches on prematurely born children (Siegel, 1984, Kalmár, Estefán, 1989, Csiky-Kalmár, 1993, Kalmár, Harkányi, Boronkai, 1992) emphasize the role of interactional characteristics, such as family milieu, intellectual stimulation and a significant effect of child-rearing attitude (P. Balogh, 1993).

## **Circumstances and methods of our research**

### **1. Aims of the research**

The aim of our research was the longitudinal examination of 30 prematurely born children. We intended to answer the following questions:

1. Whether and to what extent does prematurity as a biological risk factor influence the child's psychic and mental development and his/her social integration if the perinatal anamnesis is negative and if there is no other risk factor beside the premature delivery

and the endangered pregnancy? How do social environment and the family's child-rearing influence the child's intellectual development and academic achievement?

In order to answer these questions, we examined the children's intelligence quotient, visual-motor coordination, performance on tests measuring school maturity at the age of 6, and we examined how successful they were at school at the end of the first and the fourth school year.

2. In our research we also wished to determine which tests can predict school maturity and the fulfilment of school requirements.

## **2. The sample**

The sample consisted of 30 prematurely born children (14 boys and 16 girls) from the Child and Youth Counseling Service in Eger. Their perinatal risk level was as follows: the average of the gestation time was 33.9 weeks, the birth-weight was less than 2500g, and the average of the birth-weight was 1885g.

The children of the sample lived in town. The criteria of the selection were the birth- weight and the length of gestation: the birth weight was less than 2500g, the length of gestation was less than 37 weeks and the children had negative perinatal anamnesis.

The early anamnestic data of the examined children came from the maternity ward where they were born and from the therapeutic institutions where they were attended to because of their prematurity. At the age of 6, they were examined in order to measure their school maturity. At the age of 10, they took part in another psychological control examination. We studied how successful they became at school with questionnaires constructed for teachers at the end of the first and the fourth school year.

It became necessary to introduce control pairs in the additional psychological tests of school maturity and in the measuring of success at school. The criteria of selecting control pairs were birth-weight (more than 2500g), length of gestation (longer than 37 weeks), negative perinatal anamnesis and similarity in social economic status (SES).

## **3. Methods**

In this longitudinal study, we collected information from three major fields:

- Information on the child's biological development and environment gained by questionnaire for parents and by different psychological



achievement tests. Psychological achievement tests on the children's mental development.

- Information on the success at school gained by questionnaires for teachers.

**a) The collection of data on the child's biological development and environment at the age of 6 and 10**

**Applied methods:**

- our own designed questionnaire for the biological variables
- HOME Inventory (Home Observation for the Measurement of the Environment)
- (By the construction of the questionnaire we used the Home Scale (Caldwell and Bradley, 1979) and some items of Sears, Maccoby, Levin's Child Rearing Attitude Interview, 1957)

**Categories of the questionnaire for the parents at the age of 6:**

- Biological variables:
  - Pre- and perinatal data
  - Postnatal data
- Environmental variables:
  - Social economical status (SES)
  - Family's child-rearing attitude
  - Intellectual influences
- **At the age of 10**, HOME Inventory for parents (it is an adaptation of HOME Inventory worked out for junior school children,), henceforth "H":
  - Emotional and verbal responsivity (H1)
  - Encouraging reasonable requirements (H2)
  - Emotional atmosphere (H3)
  - Appropriate objects and experiences stimulating development (H4)
  - Active stimulation (H5)
  - Involvement of the family members in experiences stimulating development (H6)
  - Involvement of the father (H7)
  - Characteristics of the physical environment (H8)



## **b) Psychological examinations of the mental development with performance tests**

We examined children in two stages: at the start of the school and at the end of the fourth school year.

### **Tests at the age of 6:**

- Budapest-Binet intelligence test
- Goodenough's drawing test
- Bender-"B" test
- Additional psychological tests to measure school maturity

### **Tests at the age of 10:**

- Wechsler test - HAWIK
- Bender-"B" test
- Brickenkamp's attention test

## **c) Data on success at school based on the teacher's questionnaire**

*At the end of the first school year:*

Major categories of questions:

- the child's adaptation to school
- work maturity
- judgment of his/her level of mental capacities
- his/her academic achievement at the end of the school year

*At the end of the fourth year:*

Major categories of questions:

- the child's place in the hierarchy of the class, according to the teacher's opinion
- achievements in subjects
- the attention's durability, concentration ability
- behaviour problems
- academic achievement

## **4. Statistical analysis of data by computer programs**

The applied programs: BMDP 2V, BMDP 4M, BMDP 7M, BMDP PC90.

## **Interpretation and summary of the results**

In our longitudinal research we intended to answer the question whether prematurity as a biological risk factor determines the child's mental development, school maturity, academic achievement and his/her adaptation to school.

We also examined whether environmental effects, social economical status, the family's child-rearing attitude and intellectual effects stimulate or hinder academic achievement. We were interested to determine whether environmental effects or biological factors stimulate the academic achievement to a greater extent. We wanted to know which psychological tests predict academic achievement more effectively.

### **Summary of the psychological examinations (examinations at the age of 6)**

86.6 percent of the prematurely born children's intelligence quotients were in the normal range measured by means of the Binet-test. The average of the Binet test's IQ was 98.5. These results showed that birth-weight did not influence intelligence. The average of the intelligence quotient was 98.3 for the children with a birth-weight of less than 2000g, while the average of the IQ was 99.0 for the children weighing more than 2000g at birth. There was no significant difference between the two averages.

As the IQ as a global variable does not have any significance, each psychic function needs to be examined separately.

In Goodenough's drawing test, 50 percent of the examined children did not perform in the normal zone. The average of the draw quotient (DQ) was 80.3, that is to say, they performed substantially lower in the drawing test than in the Binet test. This shows that prematurely born children have a delay in their visual-motor development. This is corroborated by data in the literature which shows that prematurely born children have a delay in their visual motor maturity and the development of their psychic functions is uneven. Research on learning abilities confirms that immaturity of perceptual and motor functions and underdeveloped global perceptive apparatus play an important role in the development of learning disabilities.

In the Bender test, the greatest delay was shown in position, direction and relative position. Considering the summated scores, 13.4 percent of the examined children had an average achievement of 6-year-olds. 20 percent managed to achieve the average in position- direction, 23.4 percent in relative position and 43.3 percent achieved the average in the drawing of angles.

Prematurely born children's visual motor coordination is poor comparing to their average intelligence level. 6-7-year-old prematurely born children have a significant delay in their visual motor skills.

Table 1 shows the comparison of the results of the Budapest Binet test (BIQ), the drawing test (DQ) and the Bender test in relation to birth-weight (more than 2000g and less than 2000g).

Psychological test	Weight		
	Less than 2000g	More than 2000g	Total
BIQ	98.3	99.0	98.5
DQ	92.3	84.0	89.3
BENDER			
Total	33.2	28.5	31.5
Angle	31.9	26.6	30.0
Direction	34.3	34.5	34.4
Position	2233	1885.6	32.4
Weight	1684.2	2233.0	1885.6
N=30	N=19	N=11	N=30

*Table 1*

This table demonstrates that there are no significant differences between the two groups considering the Budapest Binet test measuring the general intelligence quotient. So, birth-weight does not determine the intelligence quotient.

### **The impact of biological variables on the development**

Birth-weight did not correlate with performance on any of the psychological tests, although it had an important role in early development (of movement and speech). Kalmár et al. (1984) found a significant relation between the three-and-a-half-year-old children's IQ and birth weight. As the age progresses, the importance of birth-weight gradually decreases.

There was only a tendency of difference in the drawing test (where  $p < 0.1$ ) between the two birth-weight groups (less than 2000g, more than 2000g).

Children born of endangered pregnancy had a minimal advantage (appearing only in one statistic variable) over children born of normal pregnancy, but prematurely. This shows that we cannot predict late consequences of the pregnancy. We can make only cautious conclusions on the minimal advantage of the endangered group. In this group the total points

of the environmental effects, too are higher than in the other group. The environmental effects can involve more care and earlier perception of problems. So the results of the tests can be influenced more directly by these positive environmental effects, and effects of the biological factors may not be manifested in the test results. By all means, early prevention is essential in pregnancy.

Examined fields	Developmental areas					
	Walking X		Speech X		Walking and Speech	
	In time	Belated	In time	Belated	In time	Belated
BIQ	100.7	84.5	101.7	88.5	86.6	98.0
DQ	90.7	79.8	87.4	32.4	83.0	98.0
BENDER						
Total points %	34.4	13	35.6	18.1	13.3	15.0
Total points of the environmental effects	75.4	60.5	70.3	59.7	61.3	60.2
Birth weight	1973.0	1967.5	1924.8	1957.1	1683.3	1652.0
N=30	n=26	n=4	n=23	n=7	n=3	n=3

*Table 2*

The data on the psychomotor development in Table 2 show that delayed walking and speech development can predict lower intelligence quotient.

### **The impact of environmental variables on development**

The effects of the socio-cultural milieu influence intellectual development substantially. There is a correlation between the Binet IQ, the environmental effects and the developmental data (walking and speech). The partial correlation coefficient also shows a relation between the general intelligence quotient (Binet IQ) and the developmental data, and between the Binet IQ and environmental effects.

According to other research findings, the biological risk factors can be eliminated in proper environmental conditions. Children whose domestic environment is especially stimulating develop advantageously.

### Summary of the results of school maturity examination of prematurely born children

56.6 percent of the prematurely born children met the requirements of school maturity.

Poor performance on the Bender test and delay in speech development predict school immaturity the most reliably. Other researchers found a relation also between delayed speech development and later mental development disorders.

There is a significant difference in the performance quotient (PQ) between the groups of school immature and mature children. There is also a tendentious difference in the Binet IQ and in the social economic status (SES). Children in the school mature have higher birth-weights, but this result is not significant.

Categories examined	The results of the examination of school maturity		Total children X
	School immature children	School mature children	
Birth -weight	1970.7	1820.5	1885.6
Gestation time	34.0	33.6	33.9
Environmental effects			
SES	23.2	27.1	25.4
Intellectual effects	20.6	23.0	22.8
Effects of the child's rearing attitude	21.3	24.	22.8
BIQ	94.1	102.0	98.5
DQ	83.2	93.9	89.2
BENDER			
Total	23.0	38.0	31.5
Angle	21.1	36.7	30.0
Direction	25	41.5	34.0
Position	26.4	37.0	32.0
Development of coherent speech in time	46.1	100.0	76.6
	N=13	N=17	N=30

Table 3

School mature children perform better on intelligence tests. **SES seems to play an important role** in this result. Based on the performance of the prematurely born children's group and the full-term born children's control group on the school maturity examination, we can conclude that prematurely

born children perform lower in the performance thinking tasks and visual memory tasks. They also have deficits in the maturity of work, work tempo, attention, concentration ability and drawing ability.

Table 3 shows the factors and other variables which can have an effect on the 30 examined children's school maturity and immaturity.

### **Relation of variables that influence academic achievement at the end of the first school year**

The Bender test's direction variable alone firmly predicts (73.3%) success at school and academic achievement. Besides this variable, the Bender test's other partial points, the Binet IQ test and the DQ also can make a distinction between children who are potentially successful at school and those who are not. The average birth-weight is a little bit higher in the group of potentially school-successful children, but this difference is not significant.

Children who are potentially more successful at school are in a more advantageous situation regarding SES and the effects of an intellectual stimulating environment.

National and international research also corroborates our results, that is, supporting environmental effects help academic achievement and success at school (Kalmár-Estefánné 1988, Kalmár 1992, 1993).

Examining adaptation to the community, we could see that environmental effects influence success of adaptation to a great extent and they also help to achieve higher mental performance.

There are significant differences between children who can adapt well and those who do not in the results of the intelligence tests, in the total points of the environmental and intellectual effects and in the effects of the child-rearing attitude.

One single test variable can predict firmly (with 70-80 percent probability) the problems at school indicated by teachers. The variable which proves to be the firmest predictor can change from problem to problem (the Bender test's position variable in 6 cases, the DQ as variable in 4 cases, the Bender test's direction variable in 3 cases, the Binet IQ only in one case- it predicts mathematical problems).

Again, the following factors account for these problems: disadvantageous SES, less stimulating intellectual effects and less tolerant and restrictive child rearing attitudes.

The prematurely born children's group had the greatest difficulty in reading. This can derive from poor visual memory and the immaturity of the comprehension of position and direction. Although the results above should

be very interesting, the small size of the sample does not permit any general conclusions.

Poor performance on the Bender test could be a predictor of dyslexia for prematurely born children, because we may also reckon with disorders of spatial perception analysis and synthesis. Prematurely born children perform lower in eye-hand coordination, visual spatial organization, short term memory and attention, which can cause functional disorder, which may result in learning difficulties later.

The psychological tests' results and the outcomes of the pedagogical control examination justify the assumption that prematurely born children's mental development is uneven and disintegrated. This type of development affects not only the psychic and mental functions but it also influences academic achievement and adaptive behaviour.

Categories examined	Success at school		
	Successful	Unsuccessful	Total children
Birth- weight	1930.95	1780.00	1885.66
Gestation time	34.00	33.77	33.93
Environmental total points	75.42	59.00	70.50
SES	27.47	20.65	25.43
Intellectual effects	24.28	17.88	22.36
Effects of the rearing attitude	23.76	20.66	22.83
BIQ	102.42	89.66	98.59
DQ	93.09	80.44	89.29
Bender total points	35.85	21.44	31.53
Bender angel	34.09	20.44	30.00
Bender direction	40.00	21.44	34.43
Bender position	36.47	22.33	82.23
	N=20	N=10	N=30

*Table 4*

By means of factor analysis, two major factors from all the measured variables emerged. The components of the first factor with highest correlation coefficients (in order) are: Binet IQ, environmental effects, early



development, the Bender test, DQ and birth-weight (with minimal value). This factor accounts for 44 percent of the variance.

The second factor consists of the gestation time and birth-weight. This factor accounts for 67 percent of the variance. The first factor determines school maturity and success at school.

According to the data in Table 4, children who are successful at school have a little higher birth-weight and more advantageous environmental effects. Their performance is higher on intelligence tests.

### **Results of the follow-up examination at the age of 10**

The aim of the final examination was to explore children's academic achievement at the end of the junior classes. We wished to know how their intelligence develops and whether prematurity as a biological risk factor influences their performance at school. We were interested in how the environmental effects and the joint effects of the family and school can modify academic achievement.

At the final examination only 26 children were available from the 30 prematurely born children. 4 children dropped out. Two children attended a special school, one child moved and the parents of one child did not require the examination.

#### **The three categories of the final examination:**

1. Environmental effects within the family: HOME Inventory
2. Psychological tests:
  - Wechsler test-HAWIK
  - Bender B test
  - Brickenkamp's attention test (d2)
3. Questionnaire for teachers on academic achievement

We introduced control pairs in the examination of academic achievement.

Within the prematurely born children's group we formed two groups on the basis of academic achievement:

- group of high performers
- group of low performers

*a, Comparison of academic achievement of prematurely born children and of the control group with t-tests*

According to the statistical results, the group of prematurely born children and the control group did not differ in their academic achievement.

There was a tendentious difference between the groups considering the teacher's judgment on permanence of attention and concentration. There was a tendentious difference considering interest ( $p < 0.10$ ). As there were no significant differences between the groups, we did not analyze the data in detail.

*b, Analysis of examination data of prematurely born children*

It seemed necessary to analyze prematurely born children's results in more thoroughly.

Firstly, we studied the relations with t-tests on one single variable. We examined the different results of the two groups of prematurely born children (the groups of high and low performers) with t-tests. We compared the results of the two groups on the HOME Inventory's total points and subscales and the performance on the psychological tests.

Then we computed correlations with the environmental variables that influence the results of the psychological examination and academic achievement.

In the second step, it became necessary to apply multivariate regression analysis, then we used discrimination analysis to distinguish the groups of high and low performers.

**Comparison of high and low performers with t-tests**

The aim of our research was to explore how environmental effects influence academic achievement. We found significant differences in the subscales of the HOME Inventory between the groups of high and low performers.

There were significant differences in the following subscales for the advantage of high performers:

H1. Emotional and verbal responsivity ( $p < 0.01$ )

H6. Involvement of family members in experiences stimulating development ( $p < 0.001$ )

There were tendentious differences in the following HOME Inventory's subscales:

H2. Realistic requirements ( $p < 0.10$ )

H4. Appropriate objects and experiences stimulating development ( $p < 0.10$ )

H8. Characteristics of the physical environment ( $p < 0.10$ )

The family's emotional atmosphere, speech culture and the common experience of parents and children have a positive impact on academic

achievement. Realistic requirements and a colourful physical environment also have a positive influence.

There was a significant difference in the total points of the HOME Inventory ( $p<0.02$ ) for the advantage of high performers. There was a tendentious difference in SES.

The average of the HOME Inventory's total points in Table 5 shows that high performers had more points:

High performers	48.83
Low performers	41.00

*Table 5*

### **Study of intelligence with the HAWIK test**

Table 6 shows the average of the performance on the HAWIK test:

	IQ	VQ	PQ
Average of all children	104.77	106.66	102.38
Average of high performers	110.39	112.94	106.17
Average of low performers	92.13	92.50	93.88

*Table 6*

The different intelligence quotients in HAWIK also distinguish the groups of high and low performers, there is a significant difference in IQ ( $p<0.001$ ) and VQ ( $p<0.0001$ ) but in PQ ( $p<0.10$ ) the difference is moderate. These results are consistent with results in the international literature.

### **Rank of environmental variables that determine academic achievement and intelligence according to the correlation coefficients**

Table 7 shows the ranks of the HOME Inventory's variables and the SES variable, which have an impact on the intelligence and performance in different subjects. (This ranking contains the tendentious associations, too.)

Performances	Environmental variables							
	1	2	3	4	5	6	7	8
HAWIK IQ	H1	H4	H8	SES	H5	H2	H3	H6
HAWIK VQ	H1	H6	H4	H2	SES	H8	H5	H3
HAWIK PQ	H1	H4	SES	H8	H5	H3	H2	
T(d2) attention	H6	H1	H4	H3	H2	SES	H5	H8
Mathematics	H1	H6	H3	SES	H8	H2		
Ecology	H6	H1	H6	H4	SES	H8		

Table 7 (*H*= subscales of HOME Inventory from 1-8, SES= social economical status)

There is either a significant or tendentious correlation between the results of the IQ and the VQ and all the environmental variables, except for H7 (involvement of the father in child-rearing).

The IQ had the strongest correlations with H1, H4 and H8 (emotional and verbal responsivity; appropriate objects and experiences stimulating development; characteristics of the physical environment). The VQ had the strongest correlation with H1, H6, H4 (emotional and verbal responsivity; involvement of the family members in experience stimulating development; appropriate objects and experiences stimulating development). Concerning PQ, the three highest values are H1, H4 (emotional and verbal responsivity, appropriate objects, experience stimulating development) and SES; H6 and H7 do not occur (involvement of the family members in experience stimulating development; involvement of the father).

Considering the attention test, the strongest environmental variables were H6, H1, H4 (involvement of the family members in experiences stimulating development; emotional and verbal responsivity; appropriate objects and experiences stimulating development) while H7 (involvement of the father) does not occur.

The rank of influence of environmental variables on performance in different subjects:

Mathematics: H1, H6, H3 (emotional and verbal responsivity; involvement of the family members in the experiences stimulating development; emotional atmosphere) H7, H4, H5 do not seem to play any role (involvement of the father; appropriate objects, experience, variety in stimulation).

Hungarian: H1, H4, H5 (emotional and verbal responsivity; appropriate objects and experiences stimulating development; variety in stimulation) H7 does not occur (involvement of the father).

Ecology: H6, H1, H3 (involvement of the family members in experience stimulating development; appropriate objects, experiences stimulating development; emotional atmosphere) H7 and H5 do not occur (involvement of the father; variety in stimulation).

To summarize the rank of environmental variables that influence the results of psychological examinations:

H1 (emotional and verbal responsivity) is ranked highest three times, H6 (involvement of the family members in experience stimulating development) is ranked highest once, H4 is ranked second twice (appropriate objects and experiences stimulating development) H6 (involvement of the family members in experiences stimulating development) and H1 (emotional and verbal responsivity) are ranked second once. H4 (appropriate objects, experiences stimulating development) is ranked third twice, and SES and H8 (characteristics of the physical environment) once.

#### **To summarize the rank of environmental variables influencing performance in subjects:**

H1 (emotional and verbal responsivity) is ranked highest twice, H6 (involvement of the family members in experience stimulating development) once. H6, H4, H1 (involvement of the family members in experience stimulating development; appropriate objects and experiences stimulating development; emotional and verbal responsivity) are ranked second once. H3 (emotional climate) is ranked third twice and H6 (participation of the family members in experience stimulating development) once.

H1 (emotional and verbal responsivity) is the most important subscale of the HOME Inventory (it is ranked first five times and it is ranked second twice). H6 (involvement of the family members in the experience stimulating development) is ranked first twice and ranked second twice. H4 (appropriate objects, experience stimulating development) is ranked third three times.

#### **Ranks of the test results as predictors of academic achievement:**

Subjects	Tests
Mathematics	VQ, T
Hungarian	VQ, T, PQ
Science	VQ, T, PQ

*Table 8*

The ranking presented in Table 8 shows that the VQ and the result of the attention test (d2) can predict performance in mathematics, while besides VQ and the attention test PQ can also predict performance in Hungarian and ecology. The rank of the tests draws attention to the fact that VQ has the most important role in predicting performance in different subjects, followed by the results of the attention test and PQ as predictors.

IQ does not play any role in the prediction according to the correlation calculation. We assume that the environmental variables support this significant role of VQ. The effects of school strengthen the effects of the family. So the role of VQ is the most important in the prediction of academic achievement.

*The predominance of verbal performance* is highlighted as an academic requirement.

Gestation time as a biological variable correlates negatively with the scores of the HOME Inventory, which might be the reason that it also correlates negatively with academic achievement. Gestation time correlates significantly with achievement in mathematics, drawing, mathematics rank, reading rank, and spelling rank. It correlates tendentiously with Hungarian, ecology, and technology.

Gestation time correlates negatively with the results of the psychological tests, with IQ, VQ, PQ, and the results of d2, but this correlation is not significant.

According to the correlation computations prematurity does not determine the results of the psychological tests or academic achievement, but **the environmental effects have a prominent role.**

There could be a substantial relation among potentially decisive variables, which justifies a multivariable analysis. Dependent variables of the analysis are the results of the psychological tests, academic achievement, and the rankings of subjects. Independent variables are SES, the subscales of the HOME Inventory and gestation time.

We were most interested in which environmental and biological variables are determinant. Table 9 shows the results of the analysis: which independent variable predicts significantly the dependent variables and which variables are determinant in themselves in this differentiated analysis.

The results demonstrate that H6 (involvement of the family members in experiences stimulating development), H4 (appropriate objects, experience stimulating development), and H8 (characteristics of the physical environment) subscales of the HOME Inventory can explain the results of the psychological tests.

Dependent variables, psychological tests		Significant predictors (independent variables)R2		Percentage of the explained variance multiple R2	
Attention test	d2	HOME	6	0.57	0.64
		HOME	4	0.07	
HAWIK	IQ	HOME	1	0.59	0.68
		HOME	8	0.09	
HAWIK	VQ	HOME	1	0.48	0.48
HAWIK	PQ	HOME	1	0.46	0.57
		HOME	8	0.11	

Table 9

Table 10 represents the environmental variables that account for academic achievement and the ranking of subjects: H1 (emotional and verbal responsivity), H5 (variety in stimulation), H8 (characteristics of the physical environment) and SES (social economic status).

Dependent variables (the position of the subjects in the ranking)	Independent variables (the significant predictors, SES Home subscales)	Percentage of the explained variance	
		R2	Multiple R2
Mathematics	H1	0.29	
	H5	0.13	
	Gestation time	0.13	0.66
	H6	0.11	
Hungarian	H1	0.40	
	H6	0.11	0.59
	Gestation time	0.08	
Science	H6	0.38	
	Gestation time	0.17	0.59
Technology	SES	0.41	
	Gestation time	0.11	0.51
Draw	Gestation time	0.34	
	H8	0.11	0.45
Music	Gestation time	0.44	
	SES	0.18	0.62
Mathematics rank	H1	0.27	0.27
Reading rank	H6	0.29	
	Gestation time	0.25	0.54
Spelling rank	H1	0.34	
	H6	0.10	0.55
	Gestation time	0.11	

Table 10



Gestation time as a biological variable occurs with every subject and in the rank of subjects except in the mathematics rank.

We also examined to what extent the results of the psychological tests influence the performance in different subjects. Table 11 summarizes our results:

Dependent variables	Significant predictors	R2, Multiple R2
Mathematics	VQ	0.36
Hungarian	VQ	0.43
Science	VQ	0.48

*Table 11*

We can see that VQ has an important role as a predictor in the performance of subjects. IQ, d2 and the Bender test do not function as predictors.

We examined with stepwise multiple discriminant analysis which variables can distinguish high and low performers within the group of prematurely born children. Potential variables that have discriminant function are the variables which have already indicated difference earlier in the examinations.

### **The differentiation of high and low performers**

**Variables:** gestation time, SES, HOME Inventory's subscales, IQ, VQ, PQ, Bender test, attention test (d2).

The rank of significant variables involved in the differentiation of high and low performers is as follows (on the basis of their strength): VQ is first, d2 test is second and the Bender test's direction and orientation variables are third.

The rating percentage is 100 percent.

The results of the discriminant analysis demonstrate that in this study VQ has the greatest percentage of the explained variance in the differentiation of high and low performers, while IQ and PQ do not play any role.

T-tests already indicated the unimportance of IQ, but PQ still appeared in it, albeit tendentiously.

Besides VQ, the second variable (on its strength) is the attention test which was also important in the t-tests.

In the discrimination of performances the direction-position variable of the Bender test is significant, while this test did not appear in the t-tests.

In the examinations at the age of 6-7, the Bender test had an important role in the prediction of success at school; the most significant variable was

direction-position. This variable also appears as the third variable in the differentiation of performance in the examinations at the age of 10.

We also wished to know which variables can predict the differences in performance besides the psychological tests. We examined the differentiation of high and low performance at school with discriminant analysis with the exclusion of the results of the psychological tests. (The applied variables were the HOME Inventory's subscales, gestation time and SES.)

The variables which play a significant role in the differentiation are H6, which stands first (involvement of the family members in experience stimulating development) and gestation time, which took the second place.

The rating percentage is 88 percent in this case.

The analysis emphasises that H6 (involvement of the family members in experiences stimulating development) can articulate the differences, the perinatal circumstances can influence only secondarily, and SES does not seem to affect it.

Summarizing the variables which can distinguish high and low performance:

- The rank of the **performance tests**: VQ, d2, Bender direction, position
- **Environmental factors**: H6 (involvement of the family members in experiences stimulating development)
- Biological factors: gestation time

As **the attention test is the second strongest predictor besides VQ**, we examined its role in connection with intelligence and academic achievement.

The substantial correlations of the attention test:

There is a correlation ( $r=0.64$ ) between the result of d2 and the teacher's judgment of students' attention (its durability and concentration ability). Both attention variables (d2 and teacher's judgement) correlate with VQ ( $r=0.68$  and  $r=0.67$ ) as well as PQ ( $r=0.36$  and  $r=0.38$ ).

The variables of attention correlate with academic achievement, and this correlation is stronger with important subjects than with intelligence. The teacher's judgement on attention correlates more with academic achievement than with the results of the attention test (d2).

## Summary

We can summarize the results of our examinations as follows:

We proved in our research that it occurs more frequently in prematurely born children than in full-term born children that they cannot cope with the tasks they have to face when they start school. According to the test results, children with problematic development have a significant delay in visual-motor coordination, which corresponds to teachers' experience that their visual memory is poor and they have problems learning to read. Attention deficit stands in the background of both the test results and the problems at school. These difficulties do not affect every prematurely born child.

In the examinations at the age of 10, environmental effects in the family have an important role in the differentiation of high and low performers. Gestation time as a biological variable also functions as a predictor to a lesser degree.

Our sample was very diverse in perinatal, gestation time, birth-weight, peri- and postnatal events. However, it was not these biological factors, but personal and material conditions in the family's environment that were significant in influencing academic achievement.

Our results reinforce the fact emphasized by several researchers that the impacts of similar perinatal biological complications such as prematurity and very low birth-weight could have different effects on the development because of the environmental conditions. A favourable family background can decrease or eliminate the negative consequences of these biological complications, while disadvantageous social circumstances can aggravate the consequences.

In the prediction of learning abilities the **Bender "B" test** plays an important role at the age of 6-7. The Bender test's direction variable preserves its predictive function, albeit to a lesser extent, until the end of the junior school age. Goodenough's drawing test and the Binet test also play a role in the prediction of academic achievement, but to a lesser degree than the Bender test.

In the psychological examinations at the age of 10, HAWIK VQ is the first variable in the differentiation between high and low performers, d2 attention test is second.

The parents' education and the intellectual effects of the environment as SES variables have a prediction function in the development of prematurely born children at the age of 6-7. At the age of 10, SES preserves its predictive function, but one HOME Inventory subscale, the involvement of the family

members in experiences stimulating development, is the most significant predictor.

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