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## The double-deficit hypothesis and prediction of dyslexia

**Abstract:** *Background:* The double-deficit hypothesis is based on research findings showing that there are correlations between phonological awareness and Rapid Automated Naming in groups of dyslexic children. The phonological awareness is a generalised term labelling all levels of conscious knowledge of the sound elements of speech. The speed of naming is a complex integration of many processes related to the cognitive and linguistic spheres and it is defined through rapid automatic naming of colours, drawn objects, numbers and/or letters. *Hypothesis:* Phonological awareness and rapid naming (as components of the double-deficit hypothesis) are associated, to a certain degree, with the speed of reading. Children at risk of dyslexia have lower scores in naming speed, phonological awareness or both. *Results:* On one hand, a significant statistic relation is discovered between the speed of reading and the phonological awareness. On the other hand, there is a moderate statistic relation between speed of reading and rapid naming. Double-deficit hypothesis is a theoretical model that can explain most of the reading disabilities (dyslexia), but not entirely.

**Key words:** phonological awareness, rapid naming, speed of reading, risk of dyslexia.

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## Hipoteza podwójnego deficytu a możliwość wystąpienia dysleksji

**Abstrakt:** *Tło:* Hipoteza podwójnego deficytu opiera się na wynikach badań wykazujących istnienie korelacji pomiędzy świadomością fonologiczną a Szybkim Zautomatyzowanym Nazywaniem w grupach dzieci dysleksyjnych. Świadomość fonologiczna jest uogólnionym określeniem na wszystkie poziomy świadomej znajomości elementów mowy dźwiękowej. Prędkość nazywania stanowi złożoną integrację wielu procesów związanych ze sferami poznawczymi i językowymi i jest definiowana poprzez szybkie automatyczne nazywanie kolorów, przedmiotów na rysunkach, cyfr i/lub liter. *Hipoteza:* Świadomość fonologiczna i szybkie nazywanie (jako składniki hipotezy podwójnego deficytu) są w pewnym stopniu powiązane z prędkością czytania. Dzieci zagrożone dysleksją osiągają niższe wyniki w prędkości nazywania, w świadomości fonologicznej lub w obydwu zakresach. *Wyniki:* Z jednej strony wykryto znacząca zależność statystyczną pomiędzy prędkością czytania a świadomością fonologiczną. Z drugiej strony, istnieje umiarkowana statystyczna zależność pomiędzy prędkością czytania a umiejętnością szybkiego nazywania. Hipoteza podwójnego deficytu jest

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modelem teoretycznym, który może wyjaśnić większość nieprawidłowości w czytaniu (dysleksja), lecz nie w pełnym zakresie.

**Słowa kluczowe:** świadomość fonologiczna, szybkie nazywanie, prędkość czytania, ryzyko dysleksji.

## **Introduction to the problem**

### **Phonological awareness**

Recently, a considerable number of studies have confirmed that children entering school with limited knowledge of phonological units show less success in reading than pupils who have the necessary competence in this area. In general, studies of phonological awareness of young children are in two directions. Firstly, data on the development of phonological awareness in a child give information about the subsequent absorption of the reading process, and secondly, establish a theoretical basis to prove most successful types of treatment of dyslexia, as far as the research establishes a significant association between phonological awareness and learning to read. The role of phonological processing in reading disturbances is advocated in contemporary visions that are often combined by the general framework of the “phonological deficit hypotheses” (Gillon, 2004). These hypotheses support the idea that the deficit at phonological level leads to difficulties in the child development in two ways: 1) in understanding the sound structure of spoken language and 2) in the maintenance of phonological information in short-term memory – problems that lead to reading disability and orthography.

### **Rapid automatic naming**

Naming speed is a complex integration of many processes associated with the cognitive and linguistic sphere. Naming speed is typically determined by testing for rapid automatic naming (RAN), which requires naming the primary colours, painted objects, numbers and letters. The authors note that the time to refer to different stimuli depends on the increasing age and is associated with reading ability. Older children were faster at naming compared with smaller, and adolescents with better reading technique showed a higher rate than “poor” readers. Historically, the concept of rapid naming was first introduced by Geschwind and Fusillo, who tested the ability of naming colours in adults suffering from Alexia without Agraphia after apoplexy. This discovery led to Denckla & Rudel’s idea to check the naming of colours in children with reading problems. The authors found that although children know the names of colours, they are slow when naming them. The assumption made by the authors is that

difficulties in naming are somehow related to reading problems. Subsequently, the authors developed three additional tests: rapid naming of numbers, letters and objects.

### **Double-Deficit Hypothesis**

For most part, early reading researchers agree on the fact that children with impaired reading ability are not identical events. They used multiple theories to explain reading disorders. They are based on highlighting the role of different processing systems involved in reading. Double-Deficit Hypothesis is popular among researchers, who discuss the neurological components of impaired reading. This hypothesis, developed by Wolf and Bowers (2000) is based on research showing correlation between phonological awareness and rapid automatic naming among a group of children with dyslexia. The authors found that in some children disturbances in both phonological awareness and naming speed are observed.

Wolf and Bowers (2000) identify three subtypes of children with dyslexia: some display dominance in phonological deficit with little signs of deficit in naming speed, others show increased deficit in naming and to a lesser extent phonological awareness deficit; in the third subtype both deficits are present. Obviously, the second and third subtypes of children are important in this theory, since they both (with a deficit in naming speed and two concurrent deficits) may not be well-supported in therapy based solely on phonological knowledge. Even more interesting are the findings of Lovett et al (1994), which reveal that more than half of the participants in their study suffered from both deficits. Furthermore, extensive data based on twin-deficit hypothesis reveals the existence of these three subtypes in other language systems too, such as German, Dutch and Finnish (Deeney, et al, 1999). A study done by the author of this paper (Shtereva, 2010) also supports the opinions and ideas discussed above.

## **Methodology**

### **Hypothesis and tasks**

The hypothesis in this study is that phonological awareness and rapid naming are associated with reading speed. Children at risk of dyslexia have lower scores in naming speed, phonological awareness, or both. Direct tasks in connection with establishing or rejecting the hypothesis are to identify any relationship between phonological awareness, speed reading and rapid serial naming.

**Subjects**

This study examined 75 year-1 pupils (43 boys – 57.3% and 32 girls – 42.7%) from two schools in Sofia, Bulgaria. The children are without disturbances in sensory modalities and their intellect is normal. The study does not take into account the preliminary data related to language and/or other disorders.

**Description of the test battery**

I. Rhyme – Test 1: Rhyme Recognition – The child was asked to recognise whether two orally presented words rhymed. Test 2: Rhyme Production – It was composed of 10 items that ask the child to produce a rhyme when given a stimulus word.

II. Classification – Test 3, 4, 5: Identification of phonemes (initial, middle and end position). The child was required to orally produce sounds (initial, middle and end position) in the word. Test 6, 7: Categorisation of phonemes (initial and end position) – this 10-item measure asked children to identify one picture out of three that had the same initial/ending phoneme as a target picture. Test 8, 9: Categorisation Production (initial and end position). The child was asked to produce an oral response to a specific linguistic unit.

III. Manipulation Recognition – Test 10 and 11 (syllable, phoneme): The examiner presented the child with four pictures and identified each of them. The examiner then asked the child to mark the picture that showed the word that would be created when a specific linguistic unit was removed (syllable, phoneme).

IV. Blending Recognition – Test 12 and 13 (syllable, phoneme): The examiner identified four pictures for the child. Next, the examiner uttered stimulus linguistic units (syllable, phoneme) at a rate of one unit per second. The child was required to mark the picture that depicted the stimulus linguistic units when blended together.

V. Segmenting Recognition – Test 14, 15 and 16 (sentence, syllable, phoneme). The examiner made an utterance, presented by pictures (sentence, syllable, phoneme), and the child recognised the number of words, syllable and phonemes articulated by tapping a pencil on a hard surface. For example, the examiner stated “Tap this pencil for every...”. Partial points were not given.

When compiling the data, the results are reported on individual test protocols, where correct answers are marked with “1” point and wrong – with “0” points.

VI. Test 17, 18: Rapid serial naming – colours and objects. The child must name all colours or objects in the order in which they are shown as fast as possible. Time for these two tests is reported in seconds.

#### **Research on reading speed**

Bulgarian norms of reading speed and writing are used, which are promoted as criteria for mastery of written language. For year 1, it is considered that normal reading speed should be 20–25 words per minute and at the end of a literacy period, i.e. at the end of a school year – 30–40 words per minute.

#### **Procedure**

At the beginning of the first school year (in the period from September to October 2009), children were tested by means of the test of phonological awareness (PTPO). Children performed tasks in two sessions lasting between 20 and 30 minutes. At the end of the school year 2009/2010, the speed with which they read the text was researched. Subsequently, a statistical processing program called SPSS 15.0 was implemented.

#### **Results and discussion**

To prove the hypothesis that phonological awareness and rapid serial naming were significantly associated with reading speed, correlation analysis and analysis of statistical significance is made between the components of rapid naming and phonological awareness in reading speed. In order to establish the results of children's reading speed, an analysis of frequency distribution is made. The results of distribution rates and the number of participants in the study group of 75 year-1 children are presented in Table 1, which reveals that 12% (9 of them) manifest lower scores, 70.7% (53 total) determine the rate and 17.3% (13 of them) are at the upper limits of performance in terms of speed reading. Reading speed in this study is determined by the number of words read per minute, i.e. lower scores are up to 24 words per minute, average – between 25 and 59, and high – 60 words per minute. These results almost duplicate entries in Bulgarian school standards for speed reading for year-1 children.

Table 1. Frequency distribution of results in reading speed

| <b>SPEED READING</b> | <b>Frequency<br/>(number)</b> | <b>Percentage<br/>(%)</b> |
|----------------------|-------------------------------|---------------------------|
| LOW                  | 9                             | 12.0                      |
| NORMAL               | 53                            | 70.7                      |
| HIGH                 | 13                            | 17.3                      |

Correlation is defined by the following criteria: correlation (Pearson Correlation) with values between 0 and 0.3 is defined as low, between 0.3 and 0.5 – moderate, between 0.5 and 0.7 – significant; between 0.7 and 0.9 – large, from 0.9 to 1.00 – very large, a minus sign in the correlation result means negative, the plus sign – a positive correlation. Statistical significance (Sig. two-tailed) or the degree of importance determines that the result is significant for values less than (<) or equal to (=) 0.05.

Correlation matrix between the speed of reading, phonological awareness and rapid naming is presented in Table 2. It was found that there is a statistically significant positive link between the results of the reading speed and phonological awareness ( $r = .451$  (\*\*);  $P = 0.00$ ) (i.e. the higher score at the 16 subtests for phonological awareness a child has, the more words per minute it can name) and moderate negative statistical relationship between speed reading and rapid naming ( $r = .504$  (\*\*);  $P = 0.00$ ) (i.e. the less the time to refer to the slide images is, the more words per minute the child can read).

Table 2. Correlation between speed of reading, phonological awareness and rapid naming

| <b>INDICATORS</b> | <b>Statistical Processing</b> | <b>Phonological Awareness</b> | <b>Rapid Naming</b> |
|-------------------|-------------------------------|-------------------------------|---------------------|
| READING           | (r)                           | ,504(**)                      | -,451(**)           |
|                   | (p)                           | ,000                          | ,000                |

As noted earlier, this study confirms the findings of several authors, which had stated that rapid naming is significantly correlated with reading. When 75 year-1 children are examined, the correlation between rapid naming of objects and reading speed is stronger ( $r = .405$  (\*\*);  $P = 0.00$ ) than between rapid naming of colours and objects and reading speed ( $r = .448$  (\*\*);  $P = 0.00$ ), but both relations were statistically significant.

In addition, statistical data processing was made to examine the correlation between reading speed and the 16 subtests of phonological awareness PTPO. This study demonstrates strong correlation between almost all tasks of phonological awareness and reading speed. Only in tasks of merging words at syllabic level, such relation has not been found ( $r = ,164$ ;  $P = ,160$ ) and in tasks of recognition and reproduction of rhyme, the correlation is weak ( $r = ,284$  (\*);  $P = 0.14$ ). Moderate dependence is found between reading speed and tasks for identification of beginning, middle and end phoneme, tasks for categorisation of initial and final phonemes, the task of reproducing words in assigned tasks, initial phoneme manipulation and fusion at phoneme level. For two tasks - saying a word by a given final phoneme ( $r = ,468$  (\*\*);  $P = 0.14$ ) and manipulating the level of the syllable ( $r = ,474$  (\*\*);  $P = 0.14$ ), statistical dependence on the speed of reading is significant. After achieving these results by means of cross-tabulation frequency, the distribution of the number of children is determined, as well as the rate and level (low, normal and high) to represent the pairs of factors (speed of reading and phonological awareness; reading speed and fast serial naming) to study a group of Year 1 students. This helped to delineate subgroups of children with poor results in reading speed and phonological awareness and/or rapid mass awareness. Finally, the data were evaluated using chi-square of Pearson ( $\chi^2$ ).

It was found that 12% of the studied children manifested lower scores in reading speed and 9.5% had lower scores in phonological awareness tasks. It is important to note that 4.1% of the children can reach slow speed of reading with poor results in tests for phonological awareness, i.e. lower scores are observed in both reading speed and phonological awareness. No child was found who showed a combination of high performance at one indicator (phonological awareness or reading) and low in others, a fact that, on the other hand, showed a correlation in the development of the studied phenomena. Data obtained by chi-square Pearson revealed a significant level of the correlated variables ( $\chi^2=17,265(a)$  и  $P=,002$ ).

When comparing the results of 75 year-1 students in terms of reading speed and rapid naming, it is found that 12% of the children have slower reading speed and 6.7% have slow naming speed. 5.3% of the children were observed to have both lower scores in reading speed and naming speed. Again, it should be noted that no child presented a combination of high performance at one indicator (rapid serial naming and reading) and low at the others. Data obtained by chi-square Pearson showed that there was a statistically significant relationship between variables – speed reading and rapid serial naming ( $\chi^2=26,949^a$  и  $P=,002$ ).

The results presented herein demonstrate that children with reading disorders are not a homogenous group in terms of phonological awareness and rapid naming. Last but not least, the data in terms of deficits in phonological awareness is only one part of reading disorder. Of children from first grade with slow reading speed (risk of dyslexia) only 36% had poor results in phonological awareness tasks. Low results in tests for rapid automatic naming account for the other 24% of bad-reader cases. Simultaneous presence of both lower scores in children with slow reading speed is observed in 14% of them. About 26% remain bad readers, whose lower scores in reading speed cannot be explained either by developmental disorders in phonological awareness, or by poor managing of speed tests, or by the presence of both deficits. In this sense, the Double-Deficit Hypothesis cannot fully explain the existence of reading disorders. This is most likely because orthographic factors, including disturbances in visual skills (such as the Triple-deficit Hypothesis by Badian), are not taken into account.

## **Conclusion**

The opportunity to identify and meet preschool children's special educational needs in order to deal with them when they're learning to read, has a huge social, economic, educational and therapeutic value.

This study demonstrated the presence of significant statistical relationship between the reading speed results and phonological awareness, and statistically significant moderate correlation between reading speed and rapid naming. In more detail, the relationship between reading speed and phonological awareness was revealed in the survey: (1) a significant statistical relationship between reading speed and pronouncing the final phoneme, and manipulation at syllabic level, (2) moderate correlation between speed reading tasks and identification of initial, middle and final phonemes, tasks for categorisation of initial and final phonemes, tasks of reproducing words with a given initial phoneme; tasks to manipulate and merge at phoneme level, (3) a weak correlation with reading recognition problems and doing rhymes, (4) only the correlation between reading speed and the tasks to merge syllables was not established.

In conclusion, the study demonstrates the role of phonological awareness and rapid naming as predictors of subsequent success in the mastery of reading. Data on the development of phonological awareness and naming speed of children allow early identification of risk signs of dyslexia, i.e. Double-deficit hypothesis is a theoretical model that can explain most of reading disorders (dyslexia).



On the other hand, this study provides a basis for developing and implementing successful therapeutic practices for dealing with reading disorders.

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