FORMING PHONETIC MEMORY IN THE COGNITIVE PROCESS OF CHILDREN AND ADULTS – REFLECTIONS FROM RESEARCH

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KSZTAŁTOWANIE PAMIĘCI FONETYCZNEJ W PROCESIE POZNAWCZYM DZIECI I DOROSŁYCH – REFLEKSJE Z BADAŃ

ABSTRACT Memory processes play a special role in the cognitive development of both children and adults. In the course of personal activity, more and more new objects and phenomena become familiar. Sensory, visual, auditory and kinesthetic sensitivity then expands. In relation to reading, visual and auditory memory makes it possible to reproduce acquired graphic signs, to perceive the distinctive features of letters and sounds. The information stored in memory enables the reader to access the knowledge he or she possesses, thus ensuring the continuity of information processing (Jagodzińska, 2003). Research exploring direct memory among adults was conducted by, among others, George A. Miller (1956). He found that, irrespective of the type of material being remembered, the range of direct memory is between 5 and 9 elements, or 7±2 elements. An element can be any memorised content, e.g. a digit, a phoneme, a word or a sequence of digits, phonemes or words. This range has been called the ‚Miller magic number'. On the other hand, Edyta Gruszczyk-Kolczyńska (2005) stated that children's memory is dominated by involuntary memory and is closely linked to action. She also accentuated that the majority of research on memorisation is conducted among adults. With regard to children, the mechanisms of retrieval from memory are rarely explored. Following the above and the research findings of G. A. Miller (1956) and Alan Baddeley (1992), I decided to investigate phonetic memory among pre-school children. The study took place in 2018 with a sample of 260 six-year-olds and was conducted in two stages (January, June)[1] .

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ABSTRAKT W rozwoju poznawczym zarówno dzieci, jak i dorosłych szczególną rolę odgrywają procesy pamięciowe. W trakcie aktywności własnej poznajemy coraz więcej nowych przedmiotów i zjawisk. Wzrasta wówczas wrażliwość zmysłowa, wzrokowa, słuchowa i kinestetyczna. W odniesieniu do czytania pamięć wzrokowa i słuchowa pozwala na odtwarzanie poznanych znaków graficznych, dostrzeganie cech dystynktywnych liter i głosek. Przechowywane w pamięci informacje umożliwiają czytającemu dostęp do posiadanej wiedzy, zapewniając w ten sposób ciągłość przetwarzania informacji (Jagodzińska, 2003). Badania zakresu pamięci bezpośredniej wśród dorosłych prowadził m.inn. George A. Miller (1956). Stwierdził on, że niezależnie od rodzaju zapamiętywanego materiału, zakres pamięci bezpośredniej wynosi od 5 do 9 elementów, czyli 7±2 elementy. Elementem może być każda zapamiętywana treść, np. cyfra, fonem, słowo czy ciąg cyfr, fonemów lub słów. Zakres ten został nazwany „magiczną liczbą Millera". Z kolei Edyta Gruszczyk-Kolczyńska (2005) stwierdziła, że u dzieci dominuje pamięć mimowolna i jest ściśle związana z działaniem. Uzasadniła również, że większość badań dotyczących zapamiętywania prowadzona jest wśród dorosłych. W odniesieniu do dzieci mechanizmy odtwarzania z pamięci są rzadko badane. W odniesieniu do powyższej tezy, wzorując się na ustaleniach G. A. Millera (1956) i Alana Baddeleya (1992), postanowiłam zbadać pamięć fonetyczną wśród dzieci przedszkolnych. Badanie odbyło się w 2018 roku na próbie 260 sześciolatków w dwóch etapach (styczeń, czerwiec).

SŁOWA KLUCZE procesy poznawcze, pamięć bezpośrednia dzieci i dorosłych, pamięć fonetyczna, mnemotechniki, efektywność czytania

1 / INTRODUCTION

Given that the essence of reading lies in decoding a written text and understanding it, there is no doubt that this process requires the involvement of cognitive functions including attention and memory. According to some researchers (Bogdanowicz 2006; Krasowicz-Kupis 2006; Oszwa 2006; Wagner, Torgesen 1987; Wieczorek, Łockiewicz, Bogdanowicz 2016), three essential elements play an important role in reading skills: phonological (phonetic) awareness, rapid automatic naming and verbal short-term memory. According to Grażyna Krasowicz-Kupis (2002), auditory perception cannot be assessed without evaluating the functioning of verbal memory. Thus, memory ensures the correct course of cognitive processes and forms the basis for learning and the acquisition of new skills in both reading and writing.

One of the traditional measurements used in research concerned the extent of direct (short-term) memory where any memorable content could be an element (Miller 1956). Over time, researchers have begun considering short-term memory as working memory. A. Baddeley and G. Hitch (1974) developed a ground-breaking theory of working memory as the construct responsible for both storing and processing information. It has a key function in human cognitive activity, as the control and processing of information takes place with its participation. Furthermore, A. Baddeley (2007) added that working memory is an information storage system that is subject to attentional control and supports the performance of complex cognitive tasks.

The model presented by A. Baddeley and G. Hitch (1974: 47–90) assumed that memory is a multicomponent system responsible for storing and controlling information processing. In view of this, working memory plays an important role in complex human cognitive activity such as learning or reasoning.

This model applied to both adults and children. Initially, it comprised three subsystems: a *central executive* system and two subordinate memory subsystems called the *phonological loop* and the *visuospatial sketch pad*. The so-called ‚phonological code', which affects the ability to organise information in memory, has an intermediate function between long-term and short-term memory and is referred to as *‚working memory'*, consisting of a central management system and the two subsystems mentioned above. The main role of the phonological loop is the short-term storage of phonological information. In a more recent development of this model, A. Baddeley (1992: 55–69) distinguished between two information storage mechanisms:

passive one (*retention*), is possible due to the existence of a phonological store, but its memory trace decays in about 2 seconds;

active one (*rehearsal*) sustained through a process of repetition (the so-called articulatory loop) that leads to the encoding of linguistic material presented in the auditory and visual modalities.

There is consensus about the primary role of working memory. Researchers (Baddeley, Hitch 1974; Cowan 2005; Conway, Jarrold, Kane, Miyake, Towse 2007) emphasise that working memory, with its limitations, plays an essential role in higher-order cognition. That is, it is involved in abstract thinking, specifically planning, reasoning, problem solving, decision making, reading or more generally language processing, and mental arithmetic.

Nowadays, according to G. Krasowicz-Kupis (1995) and Małgorzata Jagodzińska (2008), a number of methods and tests are used to study working or articulatory memory. These methods refer to elements used in the measurement of short-term memory capacity by G. A. Miller (1956) or the phonological loop of A. Baddeley (1992). It is worth mentioning that the importance of the phonological loop is also discussed by John R. Anderson (1998: 198–201) and Daniel L. Schacter (2003: 53–35), who reports the results of studies using brain imaging methods, as a result of which the location of the phonological loop can be determined.

2 / RESEARCH RESULTS AND INTERPRETATION OF THE CONDUCTED STUDIES

The formation of direct memory in children's cognitive process is important in synthesis and word analysis and in the acquisition of reading and reading comprehension skills at each stage of education. Therefore, the aim of the study was to determine the growth of phonetic memory of six-year-olds.

The test consisted of sounding out a series of vowels (i, y, e, a, o, u), starting with the first two phonemes (i, y). The child who participated in the study had a task to reproduce them in the same order in which they were presented. The researcher then used a gradation of difficulty according to Baddeley's articulatory loop, sounding out an increasingly longer series of vowels (i, y, e / i, y, e, a / i, y, e, a, o / i, y, e, a, o, u). The child was expected to repeat the vowels heard until a repetition error was made. The maximum length of the repeated row was a measure of the extent of direct memory.

Loud vowel sounding engaged the central executive system, while memorisation (phonetic looping) engaged memory and contributed to its capacity.

In the following study, phonetic memory comprised the dependent variable. The independent variables were gender, duration of preschool attendance, place of residence, and parental education. These findings resulted from the methodological concept adopted on the basis of knowledge about the formation of reading skills among children.

The aim of the research was to test the effectiveness of phonetic memory training in a group of six-year-olds in dynamic and static terms. In the first one, the aim was to answer the following question: to what extent do the examined children differ in terms of the rate of phonetic memory growth in a six-month interval? On the other hand, in the second approach, the question was as follows: are there statistically significant differences regarding the phonetic memory of preschoolers in relation to socio-demographic factors?

Analysis of the percentage distribution of the results allowed us to determine the preliminary conclusion that there was an increase in phonetic memory in the six-year-olds surveyed between the first and second measurements. Although a slight increase in the percentage of children achieving the lowest levels of phonetic memory (level 2 and 3 – by 7 percentage points) was observed, a decrease of 16 percentage points was evident for the subsequent levels (4 and 5). At the same time, a clear increase in the percentage of children achieving the tenth level of phonetic memory or higher could be noticed – by more than 6 percentage points.

The analysis of the results of the phonetic memory test among six-year-olds also showed that the lowest level of phonetic memory (2 elements – vowels: i, y) was recorded in the first stage of the study (January) and only among two children (0.8%). This result caused concern, as as working memory dysfunction is the underlying mechanism for many disorders, such as phonetic-phoneme hearing. Nonetheless, by the second stage of the study (June), it appeared that these children had already scored higher (girl – 2, boy – 4). In the second stage of the study, the lowest level was found to be the second level (3 elements – vowels: i, y, e), which was noticed among 4.2% of the children (3 girls and 8 boys).

In contemporary literature, the ‚magic number 4' proposed by Nelson Cowan (2001) competes with Miller's ‚magic seven'. When analysing the performance of memory tasks in which the portioning of material and its repetition were impeded, N. Cowan noted that the performance of the subjects ranged from 3 to 5 items, i.e. 4±1. That is, the limited capacity of short-term memory is related to the limited capacity of attention, i.e. only 3 to 5 items can be held in attention at any given time. Thus, the results of the six-year-olds tested in the second measurement, indicating a second level of phonetic memory (3 elements), were within the norm proposed by N. Cowan.

In practice, it appears that it is possible to exceed this range through the use of various strategies such as repetition, portioning of material or the use of other memory systems during memorisation. I found this effect in an ongoing study of phonetic memory among six-year-olds in both the first and second stages of the study.

The maximum phonetic memory score in the first stage of the study was 26 levels (27 vowels), while in the second stage there was an increase of 8 levels in this skill area (36 phonemes). Taking into account the gender variable in both stages, the highest score was obtained by girls. Among boys, the proportions were much lower (first stage – 16 levels; second stage – 22 levels) and involved the same boy. Among children who obtained the highest score for phonetic memory, during the study characteristic techniques of voiceless repetition, effective memorisation and retention and extraction of information from memory were observed. From the analysis presented, the best results were obtained by two children when I asked what helped them to remember vowels so well? The girl explained that she created images in her mind of objects which names began with the vowel given to remember. From her further explanation, it appeared that she used mnemonics. The boy, on the other hand, explained that he imagined a computer screen on which vowels were arranged and, by rolling his eyes, sounded out the memorised phonemes in order. When asked, who taught you this? He replied – „it's easier that way".

In an attempt to explain the phenomenon of this strategy which facilitated the children's process of encoding correctly in memory and resulted in a high level of phonetic memory, I interviewed the teachers who taught the children participating in the study. When asked whether they were teaching the children mnemonics, they denied. My observation was that the children who showed high phonetic memory also had high mathematical aptitude.

The phenomenon of children's extraordinary ability to remember a range of sounds can also be explained by a construct that A. Baddeley (2012) called the visual-spatial sketchpad. The author describes this construct with reference to adult research findings. However, it belongs to a poorly understood subsystem of working memory. While attempting to describe it, the authors also drew on findings on visual and spatial imagination obtained by other researchers.

In contrast, my research indicated that the visuospatial sketchpad may also be used by some children. I would add that M. Jagodzinska (2008) confirmed the existence of such a system, underlying the fact that it plays a key role in people in professions such as architects, engineers and technicians.

As for the next results of the study, in addition to absolute numbers and numbers in percentage, I introduced three measures of variability to estimate the phonetic memory data: mean, standard deviation and median. The mean number of phonetic memory levels for the first stage of the study took on a value of 4.72, and 5.30 for the second stage, while the standard deviation (due to the dispersion of results) took on values of 2.336 for the first stage and 3.157 for the second stage. In both measurements between the first and second stages of the study, an increase in phonetic memory skills was evident which was higher among girls (mean: 4.75 and 5.53; standard deviation: 2.533 and 3.626) than among boys (mean: 4.69 and 5.08; standard deviation: 2.142 and 2.636). On the other hand, the median as the middle value of the study set was 4.00 in the first stage and 5.00 in the second stage and only among girls was it higher in relation to boys.

These analyses also showed that in both the first and second stages of the study the largest number of six-year-olds achieved Level 4 (30.0% and 30.8% respectively) and Level 5 phonetic memory (20.8 and 18.8% respectively), i.e. the largest number of children memorised and repeated 5 and 6 vowels, thus falling within G's range of direct memory. A. Miller. Below these two levels in the first stage were 25.8% and in the second stage 18.8% of the children tested. In contrast, above levels 4 and 5 of phonetic memory, there were 23.5% of children in the first stage and 31.5% in the second stage. In both sets, a significant increase in phonetic memory was evident among the children surveyed with a higher increase among girls than boys.

The significant increase in the standard deviation may suggest that there was an increase in the polarisation of measurement results among children in the second stage of the study. In other words, higher outliers appeared in the dataset which, although resulting in an increase in the mean value for the whole sample, do not necessarily indicate an even increase in phonetic memory among all children. To explore it further, it was necessary to carry out statistical tests, the results of which are presented in the latter parts of this article.

One of the independent variables of the study was the duration of the children's attendance at kindergarten. Following this a question arises, whether it differentiated phonetic memory among children participating in the study?

Due to the characteristics of the phonetic memory distribution deviating from a normal distribution (phonetic memory at first stage: skewness = 3.920; kurtosis = 28.653; phonetic memory at second stage: skewness = 4.527; kurtosis = 33.385), the differences between the mean values obtained in the subgroups of the period of attendance at kindergarten were subjected to the non-parametric Mann-Whitney U test. It allowed the rejection of the null hypothesis according to which children at the second stage who attended kindergarten up to 3 years and children who attended kindergarten from 4 to 5 years represent the same level of phonetic memory – that is, children who attended kindergarten from 4 to 5 years obtained phonetic memory scores at the second stage statistically significantly higher than those who attended kindergarten up to 3 years. Such correlations were not found at the first stage of the study where the duration of attendance at kindergarten did not statistically significantly differentiate phonetic memory scores.

As far as remaining variables are concerned, i.e. parental education, this variable was not found to differentiate significantly children's phonetic memory ($p > 0.05$). The analysis of the results of the non-parametric Mann-Whitney U test led to such conclusions. On the other hand, in the variable of place of residence, the results in both measurements showed that children residing in smaller towns (less than 100 000 population) obtained statistically significantly higher phonetic memory scores than children residing in larger cities (more than 100 000 population).

In order to find a possible explanation of such results, I asked the parents of the children how much time they spend with their children on learning to read and what they pay special attention to these skills. The feedback showed that parents who lived in smaller towns spent more time with their children and paid more attention to reading skills. On this basis, it is possible to conclude – with great caution – that parents from small localities were extending the pre-school training in their children's reading acquisition as part of their home education, thus developing their phonetic memory.

3 / SUMMARY AND CONCLUSIONS

The results of my research on phonetic memory taking into account the phonological loop of A. Baddeley are significant for the effective support of children's mental development. The analyses showed that there was a clear increase in this skill between measurements, and this result indicated the effectiveness of training among the children studied.

As for the independent variables, i.e. parental education, this variable was not found to differentiate significantly. children's phonetic memory. However, in the gender variable, both measurements showed a higher increase in phonemic memory skills for girls than for boys. On the other hand, as for the variable related to the place of residence, both measurements showed that children living in smaller towns achieved slightly higher phonetic memory scores than those living in larger cities. This relationship was explained by the parents' statements which indicated that parents from small towns were more likely to extend their children's pre-school training in reading acquisition than parents from large towns.

The most significant correlation was shown by the results of the test of the first and second measurement of phonetic memory concerning the period of attendance in kindergarten. The groups of children attending kindergarten for 4 to 5 years had significantly higher phonetic memory scores than children attending kindergarten for a shorter period (up to 3 years). This means that phonetic memory exercises consolidated over several years of pre-school attendance had better results than those compensated for in a short period of time. Thus, **the longer the duration of support for pre-school children in developing phonetic memory, the better the effects on children's development and cognitive abilities**.

While concluding the characterisation of phonetic memory among the six-year-olds studied, I would like to devote a little more attention to the importance of the phonological loop in supporting and developing children's mental abilities. When it comes to the construct of the phonological loop, A. Baddeley (1998: 55–59) showed that the more information it includes (i.e. retains in working memory) the better the child's mental abilities. On the basis of a study of pupils who had difficulty communicating, A. Baddeley (1998: 58) formulated the hypothesis that these difficulties could be related to the limited capacity of verbal memory and therefore also to the inadequate functioning of the phonological loop. This observation was confirmed by E. Gruszczyk-Kolczyńska (2005: 45–46) who stated that under the influence of mathematics education (implemented according to the *Child Maths* concept), pupils show greater proficiency in solving tasks with content. This is caused by the fact that they are able to retain more and more information in their minds (in short-term memory). As a result, they are able to make the calculations required to solve tasks more efficiently and can more easily establish cause and effect relationships.

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