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PHONOLOGICAL AWARENESS AND MENTAL LEXICON
DEVELOPMENT OF TESTING ENABLING
ONLINE TEST SYSTEM DEVELOPMENT AND TESTING THE
FUNCTION OF EFFICIENCY

THESES OF PHD DISSERTATION

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Introduction

People who are able to read and write are the basis of the social and economic development in the 21st century, therefore it is strategically crucial for a society to make sure that the members possess reading skills on an appropriate level. If we consider the issue on an individual level, it is satiable that good reading skills help people gain knowledge and to acquire information (Molnár & D. Németh, 2006).

József Nagy (2004) interprets reading ability as a psychic system. He describes it as a complex system, which consists of specific routines, skills and knowledge. In order to understand the text in details, it is necessary for all the components to work. The failure of any of the components causes damage to the development. The success of the learning process in case of reading is determined by several components. Among these it is important to mention the ones related to language skills (Lonigan, Schatschneider & Westberg, 2008). Just as in the case of the process of speech understanding, the organization of the different levels of language is necessary for the interpretation of reading (Gósy, 2010). These linguistic levels (phonetic, semantic, syntactic, pragmatic) cooperate and integrate into the system during the reading process (Kamhi & Catts, 2012). In order to understand the text, the reader needs to understand the relationship between speech and phonetics (Konza, 2014). Several researchers specialized in reading skills confirmed that phonetical consciousness and vocabulary plays a significant role in the early development of reading skills (Cooper, Roth & Speece, 2002; Storch & Whitehurst, 2002; Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg & Poe, 2003; Mody, 2003; Gray & McCutchen, 2006; Rvachew, 2006; Copeland & Calhoon, 2007; Vloedgraven & Verhoeven, 2007; Phillips, Clancy, Menchetti & Lonigan, 2008; Deacon, 2012; Carson, Gillon & Boustead, 2013; Wackerle, Hollman, Schmitt, Brad, Field, Rodriguez & McConnell, 2013). As a result of these researches, the areas of reading acquisition were rearranged and those parts which could be taught in classroom environment in English-speaking territories were reconsidered. These were defined as the following: phonetical consciousness, knowledge of letter-sound relationship, developed vocabulary, fluent reading and strategies used during reading comprehension (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001). Later these five components were expanded with verbal expressiveness (Konza, 2014).

Almost all the abilities used for producing speech are important also in the case of the reading process (Józsa & Steklács, 2012). Even though the predictive sense of phonological consciousness was proved to be present at the early stage of reading acquisition, many factors could not be defined. It would be also crucial to investigate how phonological awareness and the elements of the mental lexicon influence the acquisition of reading. When we examine the dynamics of the development of reading, phonological awareness is the component which is definitely needed to be taken into consideration. The decoding process of reading highly builds on the general skill of syllabic phonological awareness, which spontaneously occurs at the age of five or six and considered to be the first level of phonological awareness.

Syllabic phonological awareness is the result of a matured speech-processing system. Higher level of phonological awareness (namely, the manipulation of phonemes) is the result of reading acquisition. The cognitive development of word-reading (in case of alphabetical texts) changes in the light of phonological awareness, the processing of letter-sound relation and the type of the printed word, as well as its frequency. The development of a well-

functioning form of the word lexicon - which is part of the mental lexicon - lasts for years (*Blomert & Csépe, 2012*). Reaching the mental lexicon is supported by the phonetical coding. A wider, expanded lexicon is more favourable from the aspect of reading comprehension (*Schnotz & Molnár, 2012*). Therefore, in case of elementary students, the measure of reading development should be focused on word-level reading. During the period preceding reading acquisition, syllable-level awareness should be investigated. Throughout the first stages of reading the phoneme-level phonetic awareness should be observed, and later the lexical vocabulary, as well as the mental lexicon should be taken under scope (*Blomert & Csépe, 2012; Schnotz & Molnár, 2012*). However, these measuring methods have not been built into the educational practice in Hungary yet, as the tools, which would make the results reliable without special (e.g.: psychological) needs in the classroom, are not available. Our research aims at stopping this gap.

The influence of phonological awareness and mental lexicon on the development of the reading acquisition

Phonological awareness is one of the most influential factors in early stages of reading acquisition (*Cooper, Roth & Speece, 2002; Mody, 2003; Gray & McCutchen, 2006; Rvachew, 2006; Copeland & Calhoun, 2007; Vloedgraven & Verhoeven, 2007; Phillips, Clancy-Menchetti & Lonigan, 2008; Deacon, 2012; Carson, Gillon & Boustead, 2013; Wackerle-Hollman, Schmitt, Bradfield, Rodriguez & McConnell, 2013*). These results are important because among the many factors that influence reading acquisition, phonological awareness is the one which can be controlled by the teacher in the classroom.

The relationship between phonological awareness and reading acquisition can be determined by three elements (*Wagner, Torgesen & Rashotte, 1994; Lukatela, Carello, Shankweiler & Liberman, 1995; Troia, 1999; Elbro & Pallesen, 2002; Castles & Coltheart, 2004; Muter, Hulme, Snowling & Stevenson, 2004; Hatcher, Hulme, Miles, Carroll, Hatcher, Gibbs & Snowling, 2006*):

1. The development of phonological awareness affects reading (*Wagner, Torgesen & Rashotte, 1994; Hatcher et al, 2006*).
2. The child develops phonological awareness through the reading process (*Morais, 1991*).
3. The development of phonological awareness and reading acquisition during the first stages are two-way processes. The development of early phonological awareness supports the early development of the recognition of words which helps the development of more complex phonological knowledge (*Perfetti, Beck, Ball & Hughes, 1987; Cataldo & Ellis, 1988; Castles & Coltheart, 2004*).

In the case of young children (kindergarten aged ones) phoneme awareness is the component which serves as a predictor of the success of reading later (*Ehri et al, 2001; Stanovich & Stanovich, 2003; Bowey, 2005; Hulme, Bowyer-Crane, Carroll, Duff & Snowling, 2012; Melby-Lervåg, Lyster & Hulme, 2012*). If we consider the successful acquisition of reading, phoneme awareness plays a significant role in three ways:

1. Phoneme awareness serves as a platform for children, which helps them recognize that the sounds produced in speech are represented in the alphabet.

2. Phoneme awareness helps the children to be able to recognize the systematic phoneme-grapheme relations, which sets a system for the development of phonological representations, and therefore serves to support fluent word-recognition.
3. Phoneme awareness helps in decoding the unusual, irregular words (*Al Otaiba, Kosanovich & Torgesen, 2012*).

Spreading human culture and developing individual knowledge are built upon the comprehension of information gained through reading (*Kaneko, 2013*). Therefore, in the last few years the effective teaching of reading skills has become a crucial question (*Nagy, 2004; Józsa & Steklács, 2009; Molnár & Józsa, 2006; Józsa & Józsa, 2014*). Research on reading on the one hand investigates the size of the mental lexicon, while on the other hand, psychological and linguistic researches are focused on the vocabulary, both in qualitative and quantitative sense. If we consider the quantitative aspect, it circles around the size of the mental lexicon, counting the number of words, whereas the qualitative method takes meaning as the focus point. The bigger the mental lexicon is, the better the recognizing function works, and higher are the chances for further cognitive processes (*Thorndike, 1973; Sternberg & Powell, 1983; Nation, 2006; Schmitt, 2010; Schmitt, Jiang & Grabe, 2011; Kaneko, 2013*).

Vocabulary helps the individual to comprehend the texts, at the same time reading is the best way to develop vocabulary. Reading in relation to vocabulary not only results in quantitative ways, but also improves the individual's conceptual system (*Czachesz, 1999*). The available set of words are continuously reconstructed, the holistic view transforms into a more detailed, systematic representation (*Walley, 1993*). The word reading skill is a precondition for reading skill acquisition (*Oakhill, Cain & Bryant, 2003; Rayner, Pollatsek, Ashby & Clifton, 2012*). In order for the reader to be able to read all the native words, it is necessary to possess a working system of letter-reading, as well as to possess a critical vocabulary, consisting of the most common 5000 words (*Nagy, 2004*). The students arriving to school are very diverse, their vocabularies are different. Those children who come from an environment rich in verbal stimuli of high vocabulary, are likely to become highly skilled language users and will easily acquire the new words (*Catts, Fey, Tomblin & Zhang, 2002*).

The strong correlation between vocabulary and reading comprehension has been recognized for decades by professionals (*Singer, 1965; Spearitt, 1972, Scarborough, 2001; Perfetti, 2007; Oakhill, Cain and McCarthy, 2015*). Vocabulary development, which is about 70-80% of the reading comprehension, is a precursor to understanding, (*Bromley, 2007*). The decoding of letters into words does not make sense if these words have no real meaning, as real meaning is the most important part of reading process. Students with wider vocabulary are more likely to reach comprehensive reading, which supports the further deepening of their vocabulary (*Konza, 2014*). Those children who come from less educated backgrounds, can only have access to a narrower range of expressions and possess poor vocabulary (*Biemiller, 2005*). It is more difficult for them to reach fluent reading comprehension, the usage of self-serving reading and vocabulary expansion are less likely. Their lag will show further increase (*Cain & Oakhill, 2011; Blomert & Csépe, 2012; Konza, 2014; Hódi, B. Németh, Korom & Tóth, 2015*). If early intervention is not carried out, the difference between the two groups continues to grow. In kindergarten and first grade, these differences can be overcome with the right methods and programs.

By equalizing the two groups of students great achievements can be reached (*Csapó, Nikolov & Molnár, 2011, quoted Molnár, 2015*). The rates of early intervention programs analysis clearly show that the return on investment in education is the highest when programs focus on early age. During the later stages of public education only higher material investments can result in achievement (*Molnár, 2015*).

Recently, the vocabulary and the comprehension of texts are researched from a different perspective. Thus, the vocabulary is not only analysed in a quantitative, but also in a qualitative way (*Perfetti, 2007*). It was realized that it is not enough to examine the meaning in terms of quantity (high or low vocabulary) but it is also important to observe the depth of meaning attached to the words (*Cain & Oakhill, 2011; Oakhill, Cain & McCarthy, 2015*).

One of the biggest problems of public education is that the students are diverse, while teaching methods do not differ. Solution for this problem could be the establishment of a more personalized education, which should be based on regular, specific evaluation. Computer-based (online) testing can provide significant help for individualized learning and teaching (*Csapó, Molnár, Pap-Szigeti & R. Tóth, 2009*).

Empirical studies

In our research the aim was to look for a method that involves phonological awareness and mental lexicon, what is more, investigates them in broad spectrum of efficacy, reliability and the test operation, confirmed by empirical data. No such complex test system is known in our country, and the international literature is only suitable for the establishment of a sub-area of development of measuring device, therefore we combined a number of tests designed in order to establish the structure.

Our concept was to investigate areas of phonological awareness, where the visual recognition of letters is not required. In examining the mental lexicon the main focus was to investigate the semantic system of words. For this investigation we found the categories of the *Salthouse* (1993) research to be the most appropriate. The correlation of permanent structures was not explored because of the young age of the students.

Research Objectives

The main aim of the research is to develop a measure system of phonological awareness and mental lexicon on a computer-based test for 1st-3rd grade students, as well as comparing the level of development of the two areas with the development of word-reading skills.

Parts of the study are:

1. Converting contact tasks, requiring face to face survey to a computer-based form.
2. Developing of a reliable test system for classroom from the computer-based items.
3. Comparison of the precision of the individual face-to-face test data collection and computer-based test data collection.
4. The comparison of estimated classroom capacity and individual capacity levels.
5. The comparison of development in case of word reading skills, phonological awareness and mental lexicon level.

Research questions

1. Can tasks requiring the former "face to face" contact be converted to computerized environment?
2. How does the computer test accuracy correlate to „face to face" test results?
3. Can a reliable test system be set up for classroom use?
4. What differences can be observed between the estimated ability levels of grades?
5. What correlation is observed between phonological awareness and the level of development of the mental lexicon?
6. What correlations can be observed in the development of phonological awareness and word reading skills?
7. What correlation is observed between the mental lexicon and the word-level of reading skills?

Hypotheses

Seven hypotheses were formulated in order to examine the operation of the test developed:

1. Tasks that require face to face contact can be configured to a computer-based test.
2. The computer test assesses all three grades more accurately than recorded in the traditional "face to face" environment tests.
3. The computer-based test can be used in a reliable and effective way for students of 1st-3rd grades for diagnostic evaluation.
4. The higher the grades, the better scores the students achieve. The girls perform better than boys.
5. The development of phonological awareness is related to the development of mental lexicon.
6. The level of development of phonological awareness is related to the development level of word reading skill.
7. The level of development of the mental lexicon is related to the development level of word reading skill.

The process of test series

A series of tests and measurements were set, using large-scale pilot tests in several steps between 2012 and 2014. Two pilot studies and two large-scale studies were compiled to measure the various capabilities. Traditional testing procedures described in the literature section were adapted to computer-based environment. The first pilot study investigated the reliability of the test measuring the developmental level of phonological awareness and mental lexicon. In the second pilot study the test, requiring face to face contact, was compared to the computer-based test.

Three test versions were compiled to measure the two sections (phonological awareness and mental lexicon). In order to ensure the comparability, anchor items were used, then we

implemented a large-scale study. In order to measure reading, we adapted the version of the test measuring word-reading skills.

Presentation of the tools used in the study

Choosing the words for tasks was a key issue in task building. The selection took place from those 4000 words that *József Nagy* used. From these words we selected the nouns, verbs, adjectives, adverbs that were considered to be suitable for the development of the vocabulary of the instrument. Then appropriate images were matched to the words. For some words we selected several images, as they were named by the first grade students. The test materials consist of the images that were recognized by all students in the group.

During the compilation of test tasks it was essential to compile a system which can diagnose the phonological awareness and the development of the mental lexicon crucial for the early phase of reading acquisition. Since we were not familiar with this type of traditional procedure, we combined the methods.

The development of phonological awareness was used in a broad sense. Thus, a wide spectrum of phonological and phonetic level operations was determined to serve our objectives. Under the level of phonology we understood the manipulation of words and syllables, whereas under the phonetic level we understood the recursion of sounds (*Csépe & Tóth, 2008; Goswami, 2006; Konza, 2011*).

The development of mental lexicon was defined in relation to the semantic perception. Therefore, measurements suitable for receptive and expressive vocabulary and for image recognition were not used. We chose four areas which are decisive in the organization of mental lexicon (*Lukács, Pléh, Kas & Thuma, 2014*). These are accepted in the English-speaking world and the Hungarian educational practice, as well. These four areas are the main concepts, synonyms, opposites and spatial relations.

Adapting the traditional testing method in a computer-based environment is not yet entirely possible, since the analysis of recordings in the current system is not available. During the tasks the students did not have to utter a word, syllable or sound, but they responded by clicking.

As a first step nine subtests were prepared in order to find out which type of functions could be applied in the computer environment. This examination was necessary because Hungarian educational assessment practices do not include either the computer-based test for these two areas, or early life stages. The literature only includes one process like this, known as the DIFER test (*Csapó, Molnár & Nagy, 2014*).

In the area of phonological awareness 5 subtests were prepared which measure the access of internal structure of words on three levels: speech sounds, syllables and the syllable structure level.

Subtests to measure phonological awareness:

1. rhyme recognition (FT1) – select idioms, proverbs and find the rhyming word pairs;
2. syllabic segmentation (FT2) – determination of the number of syllables in words;
3. establish sound identity – recognise the sound in the word (FT3);
4. voice analysis (FT4) – recognise the target word in audio series, decide the length of the sound;

5. voice manipulation (FT5) – the exchange of voice in word, deleting syllables

For the area of mental lexicon four subtests were compiled:

1. the main concepts (ML 1) – select a category for words;
2. synonyms (ML2) – determine the meaning of identical words;
3. opposites (ML3) – find a pair of opposite words;
4. spatial relational vocabulary (ML4) – where? whither? whence? comprehension.

Each subtest contained 25-30 items. A total of nine subtests were built of 255 items. Multiple choice items were included to be answered by clicking. Students had been listening to the tasks on headsets, therefore each student could have heard the same sound in the same quality sound.

A second pilot study examined the roles of the media on task level and personal level, both in the traditional face to face and in the computer-based environment. In the study we compared the earlier pilot study FT5 subtest with the test results recorded in the traditional environment-test results. The instruction was the same in both versions of the test, the difference was in the form of giving responses. Different response procedures had to be applied because of technology limitations. In face-to-face environment the students had to produce the answers orally, whereas in the computer environments they had to select the image which, from their point of view, demonstrated the correct answer.

We compiled the test assessing the mental lexicon and phonological awareness development level (MLFT) structure based on the results of the pilot studies. The final instrument investigated the development of phonological awareness and mental lexicon. The test assesses the access to word meaning in four areas:

1. the main concepts,
2. synonyms,
3. opposites,
4. spatial vocabulary.

The phonological awareness test in the phonology and phoneme level assesses the access to the internal structure on three levels:

1. speech,
2. syllable,
3. syllabic structure.

The phoneme level assessed five areas:

1. voice isolation,
2. speech synthesis,
3. analyzing voice,
4. identification the length of the voice,
5. voice manipulation.

The level phonology assesses four areas:

1. override syllables,
2. syllable segmentation,
3. rhyme recognition in words,
4. rhyme recognition at the end of sentences.

The items involved in MLFT were chosen based on the first pilot study, considering the reliability, and we also corrected the possible mistakes. After these, three variants of the same

test structure were built up (A, B, C). Each test consisted of 81 items, examining the development of mental lexicon on four areas, including 9-9 items (36), and phonological awareness of nine areas including 5-5 items (45 items). For the sake of anchoring, it was crucial that at least one third of every item must have been included in at least two, or in all the three test variants (*Molnár, 2013*). Thus, a total of 48 anchor items were included in the test system consisting of 164 items: phonological awareness 23 items, and 25 items in the field of mental lexicon. The anchor items were included in the test in a similar place. Strong anchoring (FAT anchor) was provided by the 24 items, which were included in all three test versions. 24-items also created the basis for anchoring pairs (AB, AC, BC). To measure the developmental level of reading, we applied the adaptive version of *József Nagy's* word reading criterion-oriented diagnostic method (*Magyar & Molnár, 2014*). Since the sample had been investigated included the first three grades of primary school we found it necessary to establish a shortened version of the test. We did not change either the determination block design or the branch system (more on: *Magyar és Molnár, 2014*), but three-stage structure was built up instead of the four-stage structure. The test structure had been formed for three levels and five different skill levels, built as a differentiating adaptive system. The five skill levels were the same as the levels had been specified by *József Nagy* (2004). The test cluster of the system included the same tasks for everyone with medium level of difficulty. The first phase consisted of four identical structures and behaviour clusters, which were distributed randomly. Students moved forward to the higher levels based on their performance on the first cluster. Entering the second level was possible by achieving 60%, who were unable to do so, had to stay on the first level. The third level could be achieved by 70%, and from there to move on to the fourth one 80% was required, reachable percent on the fifth level was 90%. With this branch structure it was ensured that all the students could solve the tasks appropriate for them.

Introduction of the sample tested

The aim was to examine the initial stages of primary school students considering the development level of phonological awareness and vocabulary. During the assessments we had been trying to make maximum use of the possibilities of the method and to involve a wide range of students. The students' performance were examined on a broad age limit. A total of 2092, 1st-3rd graders were enrolled.

Data recording

The tests were developed and recorded in the eDia system (*Molnár & Csapó, 2013*). The students filled the online tests in their institution's computer room. School lessons (45 minutes long) were provided for the students to fill in the tests. The helping teachers were given detailed written instructions - and if it was necessary oral ones – about the purpose of the tests, tasks and management, but it was forbidden to help the students to solve the tasks. Between the two tests 3-7 weeks passed.

A second pilot study used traditional data collection, as well. Room was provided by the institution for the test recordings with the students in person ("face to face"). The test was led by us, so there was no need for assistants.

Data analysis

The research results were analysed by using classical test theory and techniques of probability theory test. The classic test of theoretical analyses was carried out with SPSS software, the theory of probability test analyses were performed by using the program Conquest, the one-parameter Rasch-model. Both the technical operation of the tests and the item characteristics were examined in the analysis of data, as well as the performance of students, the person and group-level comparisons examined the estimated ability levels and the proportion of correct answers. For the reliability of pilot test results we applied indices, namely the Cronbach's α reliability indicator. For each item we looked into the value of the difficulty of the items, separation index number and determination.

In order to measure the reliability of the adaptive items with anchor items we used the WLE reliability indicator, as well as the standard error range. Logit items were used to define the behaviour of items and the work of the students.

As the students solved these tests, we had the opportunity to compare their skill levels. For the sake of comparison we standardized the skills of students as logit units, we defined the average as 500 and the deviation as 100. ANOVA and t-tests were used to identify the significant differences of the levels. The relation between the variables was investigated by the help of correlatives.

Results and their interpretations

The first pilot study confirmed the hypothesis that the test we had developed can be used trustworthily in schools over a wide range of age limits (Cronbach's α : 0.75 to 0.96). The good operation of tests was proved by the development of student results over the grades. Four subtests proved that the students possessed good levels of knowledge, regarding syllables and sounds, even at the stage of early reading skills, in line with the literature mentioned (*Ziegler & Goswami, 2006; Csépe & Tóth, 2008*). Regarding the mental lexicon it can be stated, that the knowledge level of synonyms and opposites has developed enough to provide a frame for recognizing words, which is a prerequisite for future successful reading habits. Significant differences could be detected in five subtests between the grades. The average performance difference between the second and third grade students was not significant. In all five cases the first grade students had lower performance. In the field of phonological awareness of rhyming recognition of the sounds from the analysis and speech sounds, the syllables tampering meter test performed poorly with the first grade students compared to the students in higher grades, as opposed to the field of the mental lexicon of the main concepts and spatial relational terms knowledge.

Based on the analysis of the items the second hypothesis was confirmed. Most of the items worked as expected. Each subtest included adequate number of items suitable for a wide range of ages to assess phonological awareness and the development of mental lexicon. A number of well-behaved items were sufficient to ensure the development of a complex test.

Based on the comparison of two environments it can be stated that online test reliability is higher for second graders (Cronbach's $\alpha_{FF} = 0.86$; Cronbach's $\alpha_{CB} = 0.89$), the same for third grade (Cronbach's $\alpha = 0.75$). Looking into the performance of students, we found that they performed better in the desktop environment. Adapting the task to computer environment is

confirmed by the results of research that half of the items were independent of media, and that most of the items separated the students the same way in both environments. Our hypothesis was partly verified by the fact that computer measurement worked more accurately.

The aim of the large-scale study was twofold. The first goal was to examine the reliability of the operation. Based on the research results it can be declared that the test is reliable (Cronbach's α : 0.92 to 0.93). Forming three test versions of the measurement tool we analysed their results separately to know whether they could work the same way. All the three WLE-meter person-separation reliability indexes were high (0.93). The proper operation was checked by anchor pairs used in the tests, comparing the items, and the results showed that each item located at the same range of difficulty, and their position and the item pointed movement showed slight difference. Then we examined the anchor item with re-scaled assessment tools, the reliability of which was similar to those of the three test versions (0.93). The items to ensure a strong anchorage were located in each of the test versions in a similar position, item difficulty index showed minimal difference.

Indices of difficulty of the tasks (-3.107-+2.678) covered the most part of the population. However, in the case of students with higher skill parameters differentiation was only suitable for fewer items. We examined the difficulty of the items of each dimension from the viewpoint of the ability of the students. Based on the results we found that the mental lexicon subtest was easier (0.79) than phonological awareness subtest (3.00) for students. Examining the dimensions of subtests, in line with the findings of the literature, examining the phonetic level of phonological awareness tasks proved to be the most difficult.

The average population parameter in each case was higher than 0. The average skill level of students in grades increased. Significant difference between the second and third grade students could be detected, and the third-class increased the speed of development. Comparison of dimensions showed significant correlation ($r=0.89$) between phonological awareness and the level of development of mental lexicon.

The performances of students were divided into five skill levels according to the criterion-referenced assessment. On the basis of the results it could be stated that some of the first-grade students had an optimal capacity level (8.5%) and some of the third-grade students were only in the initial stage (8%).

Background factors affecting the performance were considered to be gender and computer use. The analyses showed that they have the minimum difference (0.05), but girls possessed higher parameters of skills than boys. Significant differences couldn't be shown. The same difference was observed in the case of computer use.

The adaptive test system developed for primary school students based on the person-separation reliability index (0.9) was suitable for assessing word reading skills. Indices of difficulty of the tasks covered the level of skills of the age group examined. The progress of student achievement increased with grades. Half of the students passed the preparatory level, namely their performance exceeded 60%. The one-year learning to read was enough to reach the third level. The final stage was only reached by 20 second and third grade students, which is less than 2%. These results differ from data in the literature, according to which 27% of the second grade students reached criterion level (Nagy, 2006). None of the students reached the optimum level of performance (90%).

The word reading test and student achievements in MLFT test showed significant correlation ($r=0.482$, $p=0.01$). As grades progressed, this relationship became even stronger, which meant that parallel with the reading development of these two issues (word reading) had been evolving. For the majority of students it was true that anyone who had performed well in one test, would also perform well in the other.

The word reading test results were compared in each dimension, as well. The most important relationship could be found in the area of mental lexicon, contrary to the terms ($r=0.367$, $p=0.01$) and understanding of the main concepts ($r=0.352$, $p=0.01$). The test of phonological awareness development moderately correlated with phonological level rhyme recognition block ($r=0.380$, $p=0.01$), the phonetic level, the voice-manipulation ($r=0.382$, $p=0.01$) and long-short distinctive tones ($r=0.319$, $p=0.01$) subtests.

Research confirmed our hypothesis that the development of phonological awareness affects the reading process (*Wagner, Torgesen & Rashotte, 1994; Hatcher et al, 2006*). Those students who achieved high performance in the phonological awareness subtest, also had better word reading skills. This statement was also true in reverse, in the case of our study population, i.e. those who had low levels of skills in the area of phonological awareness, also showed low performance in word reading test. It has been proved that children is phonological awareness develop through reading (*Morais, 1991*) and the students' progress over the grades. It has been justified by the results that reading and phonological awareness mutually reinforce each other (*Chafouleas, Lewandowsic, Smith & Blachman, 1997*) at the beginning stages of reading acquisition.

It was also demonstrated that the success of reading depends on the developmental level of phonological awareness (*Csépe, 2005; Justice, 2006; Nelson, 2010; Adlof, Catts & Lee, 2010; Al Otaiba Kosanovich & Torgesen, 2012*). We studied two areas, but in the development of phonological awareness stronger correlation was shown ($r=0.463$, $p=0.01$) than in the mental lexicon development level ($r=0.437$, $p=0.01$).

We agree with the fact that verbal performance skills only takes secondary role in predictive sense of successful reading (*National Early Literacy Panel, 2008; Dickinson, Golinkoff & Hirsh-Pasek, 2010*). The two areas (phonological awareness and mental lexicon) show a significant relationship between early semantic ability and reading comprehension (*Roth, Speece & Cooper, 2002*).

Based on these it can be stated that former face to face contact tasks can be transformed into computer-based tests. This electronic test system can be used reliably and efficiently in classroom settings for grades 1-3.

Justification of the hypotheses

Seven hypotheses had been set before the research, in this chapter we intend to verify them in the light of the results.

1. Tasks that require face-to-face contact can be transformed into computer-based tests.

During the research those tasks were converted to computer environment, which previously had been used in a traditional test process. The developed tests possessed all the indicators of reliability (Cronbach's α : 0.75 to 0.96). All nine subtests contained items which

were appropriate to measure the development of mental lexicon. Thus, the first hypothesis has been proved.

2. Computer-based tests are more reliable and accurate than face-to-face tests.

Subtests seemed to function reliably in both environments. Taking into consideration the second grades, the rates were higher whereas in the third grade these were lower. In the case of the first class pupils significant difference was experienced, as face-to-face tests were proved to be more reliable than the computer-based test version. The reason for this may have been that the computer use affected their performance as they had not gained sufficient experience in the computer data recording, and in the use of the mouse. Thus, the second hypothesis has only partly been confirmed.

3. The computer-based test is reliable and effective for diagnostic evaluation of 1st-3rd grade students.

Based on the research results it can be declared that A, B, C test versions operate reliably (Cronbach's $\alpha = 0.92$ to 0.93). Testing of proper operation was confirmed by pairwise comparisons and anchor items which were used in the tests, as well. The results showed that each item located at the same range and degree of difficulty, the minimum position and the item pointed movement dependent. The anchor item with re-scaled meter (MLFT) was similar to those of the three test versions showed high values (0.93). The items to ensure a strong anchorage were located in each of the test versions in a similar position, item difficulty index showed a minimal difference. Thus, the third hypothesis has been confirmed. The developed test system is suitable for diagnostic evaluation of students' grades.

4. As the grades progress, students perform better. Girls outperform boys.

The application of probability theory test third factor was included in the grade level and gender. It can be stated that higher grade students possess higher levels of abilities. The first and second graders show slower progress than the third graders. The estimated skills of girls were higher. This difference was not statistically significant, so the fourth hypothesis has only partly been confirmed.

5. The development of phonological awareness is related to the development of mental lexicon.

To explore the relationship of phonological awareness and student achievements in the mental lexicon, we compared each dimension of each of the two areas. We found a strong correlation ($r=0.89$) between the development of phonological awareness and the level of mental lexicon. Based on the regression coefficient ($r^2=0.581$, $p<0,001$) the development of phonological awareness is responsible for the development of mental lexicon in 51.8%. This means that one component affects the development of the other components of the development, that is, those students whose phonological awareness of words was more advanced, more advanced their semantic organization in mental lexicon was. Correlation values between the different dimensions in each case assumed a moderate relationship. Phonological awareness and mental lexicon development of primary school age are developing integrated to each other. Thus, the fifth hypothesis has been confirmed.

6. The level of development of phonological awareness is related to the word reading skill development level.

Since both of the tests were completed by the students, it was possible to examine performance in the context of the two tests. In order to compare students' abilities to the test, two levels of student achievement was established in 500 and sporadic reference in 100. Correlation value between the two areas is assumed to be a moderate correlation ($r=0.463$, $p=0.01$) during the examination of the entire sample. However, these values were not consistent for individual grades. The strength of relations grew with the progress of grades. Thus, we can conclude that parallel with the development of word reading skills, phonological awareness level develop, as well. The sixth hypothesis has been confirmed.

7. Level of development of the mental lexicon is related to the word reading skill development level.

The mental lexicon development also moderately ($r=0.437$, $p=0.01$) correlated with word reading skill development. These values were not uniform either in the separate grades. The strength of relations grew with the progress of grades. Therefore, we can conclude that parallel with the development of word reading skills the mental lexicon development takes place, as well. Thus, the seventh hypothesis has been confirmed.

Summary

One of the key segments of successful integration into the society is the knowledge that students acquire in school. One of the most important milestones in the acquisition of knowledge is teaching students how to be successful readers, as learning new skills can only be done by an appropriate level of reading. A prominent international research has revealed that the renewal of school-based teaching / learning processes is necessary for the students to be able to integrate into the society of the 21st century. Researchers worldwide have strengthened their pedagogical, psychological and linguistic research, which have addressed segments that influence the reading efficiency. The application of these research results could improve the effectiveness of school education.

The key element of skilled reading is decoding which takes place easily and automatically. In order to help students reach this level of skill, they will have been going through a long learning process. This labour-intensive learning course does not work easily for all students, a number of factors has an influence on the progress. It influences the individual's vocabulary, and especially the development of the level of mental lexicon, as well as the development of phonological awareness. In order to be able to determine the developmental state of these fields a number of national and international assessment instruments have been created. However, the majority of these tests should be used only in traditional environment, which limits the students' regular measurement, evaluation, and the constant monitoring. In contrast to the expectations, public education will only be able to comply with the expectations if accurate, reliable tools will be assessable to evaluate student skill levels. The computer tests offer a new opportunity to solve this problem. It can be arranged for regular measurement of students' capability. Their advantage is that their use can be implemented immediately,

evaluation of the results is automatic, and so the teachers are not required to spend extra time with it. New types of tasks can be compiled, and provides opportunities which have not been tested yet, or just complicate the procedure for precise measurement of the areas assessed.

The purpose of our research was to develop an online system which measures the role of phonological awareness and mental lexicon in word-reading acquisition, together with their developmental level.

The test and development measurement data were carried out in several stages. During the first step the Hungarian and international tests were examined, with a view to phonological awareness and mental lexicon connected with new computer based tests which have been introduced as well as the tasks had been involved. Then we determined the areas in which we will examine the initial stages of primary school (grades 1-3.). After the selection of the vocabulary and images of the items 9 subtests were made.

In order to develop an assessment device two pilot studies were carried out in order to find out whether face-to-face tasks could be transformed into computer tasks. Each subtest was done by one class per grade. The second pilot study examined the tests in traditional and computer-aided environment. The final test was compiled based on the results of the pilot studies. After data recording we conducted the item-and personal-level studies. The second large-scale assessment of students' reading skills was tested adaptively. The two large-sample assessments provided an opportunity for a person-level comparison, as well. In this analysis the Rasch-model was used, we examined the reliability of the tests, the items and the estimated ability levels.

The practical significance of the research is that during the development of tests such an assessment device has been worked out and can be used trustworthily in classroom settings. The device is capable of assessing fields which have not been integrated into the Hungarian practice. This can be facilitated by the computer-based environment, as this form of assessment is easy, does not require any special knowledge of carrying out the assessment process and recording data, as it all works automatically. The time of taking the test is not restricted either, as it can be done any time of the day and the year. The immediate feedback makes it possible for the teacher and for the student as well, to get to know their skills within a lesson. The tests can be filled in during the school year more than once, which will ensure easy monitoring development of student' skills. The instrument is built up of three subtest in order to avoid the possibility that students sitting next to each other can solve the same tasks. The test versions also provide the possibility to fill in several versions, so the students do not meet the same test. The students' ability can be estimated accurately, which supports criterion-referenced development.

The unique character of the research is manifested in the fact that it investigates the phonological awareness and mental lexicon development on thirteen levels at the same time. Only a few researches work with such complexity. On the other hand, complex computer-based testing in our study area has not yet been realized in the Hungarian educational measurements. In respect of the international field, only a few measuring devices have existed. The participants were 1st-3rd grade students, and the results show that the test is reliable over a wide range of age limits. As a limit of the research we can mention that some of the task types had to be changed because of the technological limitations. On tasks which require individual identification we chose alternative choice-making task types.

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