PHONOLOGICAL PROCESSING AND READING IN A SEMI-TRANSPARENT ORTHOGRAPHY (POLISH)

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Abstract

Background: In the semi-transparent Polish orthography, children develop their reading skills from sound blending, through syllable and morpheme blending, to word and phrase recognition strategies (Awramiuk & Krasowicz-Kupis, 2015).

Aim: The aim of the study was to examine reading proficiency and reading strategies of year 4, 11-year-old primary school students, and to investigate the relationship between the selected aspects of phonological processing and literacy skills. We aimed to confront the newly collected empirical data with the already developed model of reading acquisition to confirm the developmental path of reading strategies.

Methods: We used a set of tests measuring phonological awareness, rapid automatized naming (RAN), working memory, short story reading, nonword reading, and reading comprehension.

Results: Most children achieved a global stage in reading, as the most frequent mistake was an entire word repetition, followed by a syllable blending, and a syllable and sound blending combined among word reading errors. Phonological awareness predicted the number of errors, and RAN - the accuracy and fluency of the short story reading.

Conclusions: Our results confirm the development of reading strategies from phonological-analytical to global in Polish. This model is consistent with other alphabetical orthographies.

Keywords: reading acquisition, phonological awareness, rapid naming, working memory, Polish

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1. INTRODUCTION

Phonological processing functions, especially phonological awareness, rapid automatized naming (RAN), and verbal short-term memory are a prerequisite for reading proficiency (Krasowicz-Kupis, 2008; Wagner & Torgesen, 1987). The development of phonological awareness affects the development of literacy (Bradley & Bryant, 1985). Children acquire first smaller, then larger phonological elements (Lipowska, 2001; Melby-Lervag, Lyster, & Hulme, 2012), which is influenced by schooling (Krasowicz-Kupis, 1997). In all known orthographies, RAN correlates with reading fluency, since both rely on common processes, e. g. working memory and relating orthographic and phonological representations correspondences (Norton & Wolf, 2012). Reading requires a combination of precision and fluency in the perception and processing of speech sounds (Nelson, 2015; O'Brien, Wolf, & Lovett, 2012), and the efficiency and pace of phonological naming correlate strongly (Vukovic & Siegel, 2006). Moreover, single words of a given text are processed in verbal short-term memory, to understand and repeat the whole phrase (McDougall, Hulme, Ellis, & Monk, 1994), hence its significance for the development of reading and writing skills (Lundberg & Hoien, 2001; Nevo & Breznitz, 2014; Rispens & Baker, 2012). Verbal short-term memory and RAN are measured with implicit tasks, and phonemic awareness – with explicit ones (Melby-Lervag et al., 2012).

Language transparency influences the difficulty of phonological awareness tasks (Geva & Siegel, 2000), word and nonword reading (Seymour et al., 2003), writing (Caravolas & Bruck, 1993; Caravolas & Volín, 2001), and reading acquisition (Ziegler & Goswami, 2005); these tasks are easier to execute in the more transparent orthographies. Therefore, phonological awareness, tested in different countries, may in a different degree predict the progress in reading (Sochacka, 2004).

Polish is a West Slavic, consonantal (Dryer & Haspelmath, 2013), semi-transparent language. The grapheme-phoneme correspondence is relatively high for reading, but rather low for writing (Awramiuk, 2006). For instance, some phonemes are represented by two different spelling patterns: /u/ can be spelled as: ó-góra (a mountain) or u-chmura (a cloud). Formal literacy education begins with a Reception Year, usually entered at the age of around five or six years (inconsistency due to recent changes in legislation), followed by six years of a primary school (including three years of early integrated education) (Polish Eurydice Unit, 2015).

Reading instruction in the elementary school is based on the sound/letter segmentation and blending (Rocławski, 2000; Więckowski, 1995), which is focused on the technical aspects of reading and called an analytic-synthetic method (Dobkowska, 2014) or a bottom-up strategy (Murawska, 2011). Simplified coursebook reading materials focus on the order of introducing letters (year 1), and their consolidation (year 2). Thus, they follow either a very rudimentary or no plot at all (e.g. providing the reader with a description instead), and include an overabundance of

the currently studied letter[1] (Dobkowska, 2014), as mostly single word decoding skills are trained. Children create their own "Albums of letters" (Lorek & Wollman, 2014), in which they practice each letter through drawing, puzzles, blending, segmentation, and other similar exercises. Such a bottom-up approach should be enriched with a top-down, holistic approach, for example by introducing authentic fiction and non-fiction texts outside of the coursebook (these are to be read aloud by the teacher), to develop children's motivation and interest to read (Dobkowska, 2014), and to promote comprehension (Murawska, 2011), as many primary school teachers do. Moreover, the Reception Year teachers combine the analytic-synthetic method with a global one, in which children recognize visually whole words of high frequency before they learn letters (Jaszczyszyn, 2010).

Krasowicz-Kupis (Awramiuk & Krasowicz-Kupis, 2014) identified the following key stages in reading acquisition in Polish: 1. Dominance of Analytical-Phonological (sound blending) Strategy, 2. Interim between Analytical Phonological to Global Word-based (syllable and morpheme blending) Strategy, and 3. Dominance of Global (word and/or phrase recognition) Strategy. Thus, phonemic awareness influences reading fluency in the highest degree in the Reception Year (corresponding to stage 1), but its impact decreases in the next two years (Krasowicz-Kupis, 2008). Similarly, usage of analytical and synthetic strategies in the first two years of reading instruction by Polish students was reported by Sochacka (2004). These theories correspond with the dual-route approach (Coltheart, 2006), which advocates a direct access to the mental lexicon (known words' recognition) or applying grapheme/phoneme correspondence (unknown words' or nonwords' decoding). Similarly, Ehri (1994) lists 4 strategies: the recognition of words included in the mental lexicon for the familiar words, and decoding, an analogy to known words, and the usage of contextual clues for the unfamiliar words not included in the mental lexicon. Polish young readers begin with blending words and subsequently advance to global word and/or phrases recognition, as their reading becomes automatized and their lexicon expands. Thus, they achieve a consolidated alphabetic stage of reading, where they automatically recognise the pronunciations and meanings of written words upon seeing them as whole units (Ehri, 2011). The logographic (Frith, 1985) or pre-alphabetic (Ehri, 2011) stage, initial in English-language reading acquisition models, might appear in the pre-literacy stage, prior to formal instruction (Awramiuk & Krasowicz-Kupis, 2014), as Polish children begin reading instruction later than English children do.

The aim of the present study was to examine reading proficiency and reading strategies of year 4, 11-year-old primary school students in a semi-transparent Polish orthography. We aimed to investigate the relationship between the selected aspects of phonological processing, key in the acquisition of reading skills: phonological awareness, RAN, and verbal short-term memory; and literacy skills: a short

[1] *Celina ma cytryny.* A sentence from a year 1 coursebook, introducing letter "c" (Lorek & Wollman, 2014, p. 11); an approximate translation: *Lucy has lemons*.

story and single nonword reading, and reading comprehension. We assumed that the dominant reading strategy should be a global one, following Krasowicz-Kupis's (2006) model of reading acquisition in Polish. We decided to investigate an older group of children, who had completed a 3-year early integrated education stage, to extend the age span already studied in Polish, as Krasowicz-Kupis's (1999, 2008) studies included 6-to-9 year old children. We also added RAN as a predictor of reading accuracy and fluency. Though its impact could be inferred from the characterisation of the dominance of a Global Strategy, RAN measures were not included previously (cf. Krasowicz-Kupis, 1999). Thus, we aimed to confront the newly collected empirical data with the already developed model of reading acquisition to confirm the developmental path of reading strategies.

2. MATERIALS AND METHODS

1. Bateria Metod Diagnozy Przyczyn Niepowodzeń Szkolnych u Uczniów w Wieku 10-12 lat. Bateria-10/12 [The Battery of the Methods of the Assessment of the Causes of Academic Failures in 10-12 year-old children. 10/12 Battery] (Bogdanowicz, Kalka, Karpińska, Sajewicz-Radtke, & Radtke, 2012): assesses literacy skills. The Battery was administered in Polish. The following subtests were used to assess:

a. Linguistic skills:

Unknown Language (based on nonwords), including tasks: minimal pairs comparison (*Max* = 25 points), sample item: *frasz - flasz*, phoneme segmentation (Max = 7 points); sample item: *pakor*, phoneme blending (*Max.* = 7 points); sample item: *z-o-r-a*, phonological memory (Max = 18 points); sample item: *moleno*;

Phoneme deletion (based on real words; Max = 10 points); sample item: *ra(m)ka (te(m)per)*;

Spoonerisms: production (Max = 5 points) and recognition (Max = 4 points); sample item: *doły mamek (cottle littage)*. Score was 1 point for every correct answer. A Cronbach's alpha for accuracy was 0.659. In calculations, we used a composite total score tapping phonological awareness (Max = 76 points).

b. Rapid automatized naming (RAN), including tasks: 1. colours naming and 2. letters and digits naming. Score was time in seconds, plus 1 second added for each error. In calculations, we used a composite total score tapping RAN.

c. Academic skills:

A short story reading. Score was 1 point for every word read correctly within 1 minute (Max = 164 points; sample item: *Prześlicznie było na wsi; It was lovely in the country*), which is a composite score for reading accuracy and fluency.

Reading comprehension. Score was 1 point for every correct answer to 4 open questions (1 question required giving 2 answers) to the short story already read (Max = 5 points).

Single nonword reading. Score was 1 point for every nonword read correctly within 1 minute (Max = 71 points); sample item: *łatysz*.

A Cronbach's alpha for all three reading measures collapsed into one was 0.813. Additionally, we identified the types of errors in the cohesive text reading task: word repetitions, reading by syllable blending, sound blending, syllable and sound blending combined, a longer pause in reading, omitting a word, to provide an additional measure of accuracy.

2. *Digit Span – WISC-R Battery* (Matczak, Piotrowska, & Ciarkowska, 1991), Polish adaptation. The subtest has 2 tasks (forward and backward). A Cronbach's alpha for the whole WISC-R Battery is: for the verbal scale (which includes the Digit Span subtest): 0.85, for the nonverbal scale: 0.76, for the full scale: 0.87. Reliability for 11;6 yr. old children: r_{tt} = 0.79, SEM = 1.32; SEE = 1.17. The validity correlation with TMS Raven test for 10;6 yr. old children = 0.45. In calculations, we used a composite total score tapping working verbal memory.

3. PARTICIPANTS AND PROCEDURE

Participants included 70 children attending a year 4 class in a state primary school in Gdansk, Poland. The children, 36 (51%) boys and 34 (49%) girls, M_{age} = 11 years, 0 months (*Min* = 9 years, 11 months, *Max* = 11 years, 7 months), completed the test individually. All students were native speakers of Polish, neither had a LD report. The children and their parents expressed informed consent for the students to participate in the study.

4. RESULTS

Reading a short story score was average for this age group, according to The Battery 10/12 manual, *M* = 89.37, *SD* = 23.73, *Min* = 16, *Max* = 138, as measured with the number of words read correctly within a minute. 13 (18.57%) children's score was low, 47 (67.14%) – average, 10 (14.29%) – high. No child managed to read the entire story correctly. Reading single nonwords score was average for this age group, according to *The Battery 10/12* manual, *M* = 38.67, *SD* = 12.50, *Min* = 14, *Max* = 67, as measured with the number of nonwords read within a minute. 11 (15.71%) children's score was low, 31 (44.29%) – average, 28 (40%) – high. No child managed to read all 71 single nonwords correctly. Reading comprehension score was average for this age group, according to *The Battery 10/12* manual, *M* = 2.73, *SD* = 0.95, *Min* = 0, *Max* = 4, as measured with the number of correctly answered questions about the text read. 31 (44.28%) children's score was low, 20 (28.57%) – average, 18 (25.74%) – high. In all three reading tasks, a discrepancy between the minimum and maximum scores occurred.

In the short story reading, children made on average 4 mistakes, *M* = 4.11, *SD* = 2.50, *Min* = 0, *Max* = 11. The most frequent mistakes were ($\chi^2(5) = 81.78$, $p \leq .001$, as measured with a Friedman test): word repetitions (*M* = 1.59, *SD* = 1.72, *Min* = 0,

Max = 8), syllable blending (*M* = 1.01, *SD* = 1.46, *Min* = 0, *Max* = 6), both syllable and sound blending (*M* = 0.89, *SD* = 0.84, *Min* = 0, *Max* = 3), a longer pause in reading (*M* = 0.30, *SD* = 0.57, *Min* = 0, *Max* = 3), omitting a word (*M* = 0.23, *SD* = 0.52, *Min* = 0, *Max* = 2), sound blending (*M* = 0.10, *SD* = 0.30, *Min* = 0, *Max* = 1). No student omitted an entire line.

A pairwise Wilcoxon test indicated that sound blending was less frequent than both syllable blending ($T = 12.0$, $p \leq .001$) and sound and syllable blending ($T = 56$, $p \leq .001$). Syllable blending was more frequent than longer pauses ($T = 121$, $p \leq .001$), omitting a word ($T = 33$, $p \leq .001$), and sound and syllable blending more frequent than longer pauses ($T = 102.5$, $p \leq .001$), and omitting a word ($T = 129$, $p \leq .001$).

We calculated Spearman rank order correlations between 1. children's age, 2. reading measures: number of words read correctly in the short story within a minute, number of errors committed in the short story reading, nonword reading, and reading comprehension, and 3. phonological processing measures: phonological awareness, RAN, digit span). RAN correlated with short story reading ($r = -0.41$) and nonword reading ($r = -0.26$). Working memory correlated only with nonword reading ($r = 0.29$). Phonological awareness correlated with reading errors ($r = -0.32$), and nonword reading ($r = 0.26$). Age correlated with the short story reading errors ($r = -0.3$).

A hierarchical multiple regression indicated that RAN predicted the accuracy and fluency of text reading, $R^2 = 0.096$, adj. $R^2 = 0.053$, $F(3,63) = 2.239$, $p = .092$, $\beta = -0.30$, $t(63) = 2.42$, $p = .018$ (Table 1). Phonological awareness predicted the number of errors in text reading, $R^2 = 0.15$, adj. $R^2 = 0.10$, $F(1,62) = 13.29$, $p \leq .001$, $\beta = -0.30$, $t(68) = 2.42$, $p = .018$ (Table 2). The apparent prediction of age (cf. Model 1 in Table 2) disappeared when the phonological awareness factor was added. Analogical models for reading comprehension and nonword reading yielded no significant results.

Table 1. Short story reading accuracy and fluency predictors—hierarchical linear regression

	Model 1			Model 2			Model 3		
Variable	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Age	-.044	.356	.723	-.226	1.875	.065	-.061	.490	.626
RAN				-.304	2.422	.018	-.244	1.927	.059
Working memory				.032	.251	.803	.118	.891	.377
Phonological awareness							.042	.321	.749
R^2		0.002			0.096			0.098	
Adjusted R^2		-0.013			0.053			0.040	
F-change		0.127			3.290*			0.103	

* $p \leq .05$

Table 2. Errors in short story reading predictors—hierarchical linear regression

	Model 1			Model 2			Model 3		
Variable	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Age	-.256	2.133	.037	-.261	2.103	.040	-.226	1.875	.065
RAN				.027	.216	.830	-.006	.052	.958
Working memory				-.063	-.493	.624	.032	.251	.803
Phonological awareness							-.304	2.422	.018
R^2		0.065			0.071			0.151	
Adjusted R^2		0.051			0.027			0.096	
F-change		0.065*			0.005			0.080*	

* p ≤ .05

5. DISCUSSION

We found that 11-year-old Polish children read a short story and a list of single nonwords accurately and fluently, and completed a reading comprehension task on a level average for their age, as expected, since no child had a LD report. However, in all three tasks, discrepancies between the minimum and maximum scores occurred, indicating substantial differences in capabilities between students. At this stage of education, children are expected to be rather proficient readers and read fluently aloud entire words. 18.57% students scored low in text reading, 15.71% - in nonword reading, and almost half: 45.71% - in reading comprehension. Likely, undiagnosed children with dyslexia were present in this group, some of the children exhibiting typical dyslexic symptoms (Lyon Reid, Shaywitz, & Shaywitz, 2003). This calls for an earlier assessment, identification, and intervention, before the problems accumulate. No child achieved a perfect score.

Krasowicz-Kupis, K. M. Bogdanowicz and Wiejak (2015) suggest that reading skills assessment should include: reading accuracy and fluency, text comprehension, and the dominant reading strategy. In our study, when reading a text, the participants made on average 4 mistakes, including: 2 word repetitions, 1 syllable blending, 1 syllable and sound blending combined, and in fewer than 0.5 cases: a longer pause, omitting a word, and a sound blending error.

We found that sound blending, characteristic for the analytical-phonological stage, was less frequent than both syllable blending and sound and syllable blending, which are typical for a more advanced interim stage. Moreover, blending errors were more frequent than longer pauses and omitting a word. Only three children made no mistakes. This suggests that most children achieved a global stage in reading, as the most frequent mistake was an entire word repetition, which is consistent with Krasowicz-Kupis's (Awramiuk & Krasowicz-Kupis, 2014) model of the development of reading in Polish. The preference for a global reading strategy in an older group of adolescents was reported in an earlier Polish study (Wieczorek, Łockiewicz, & Bogdanowicz, 2016); this study, however, did not characterize typical reading errors committed by the participants. Phonological skills decreasingly influ-

ence reading (Krasowicz-Kupis, 1999, 2008), while contextual and semantic knowledge increasingly influence it as children begin to rely on their mental lexicon, which includes an intuitive knowledge of semantic, syntactic, and orthographic aspects of words and their relation to other words (Kurcz, 2000). Moreover, our results are consistent with the dual-route theory (Coltheart, 2006), stipulating the usage of lexical processing in reading known words, since proficient readers rely on global strategies (Bogdanowicz & Krasowicz-Kupis, 2005; Snowling, 2004).

We found that phonological awareness and age correlated moderately with reading errors (negative correlation), and weakly with nonword reading. Moreover, phonological awareness, but not age, predicted the number of errors committed in the short story reading (as phonological awareness added to the model captured all the variance previously explained by age). The literature suggests that phoneme awareness, together with grammatical knowledge and speech rate, predict longitudinally 90% of variance in reading skill (Muter & Snowling, 1998). Blending errors in reading committed by the participants in our study might be apparent especially in more difficult, longer words, as Polish, when compared to other languages, has complex syllable structure, and is an inflectional, strongly suffixing language (Dryer & Haspelmath, 2013). In future studies, we would like to examine reading difficulties with regard to word structure and difficulty, e.g. the number of syllables or the complexity of consonant clusters.

We found that RAN correlated weakly with nonword reading and moderately with short story reading, which was confirmed in the regression analysis, as RAN predicted the accuracy and fluency of the short story reading. This is consistent with earlier studies in a variety of languages (Norton & Wolf, 2012). For example, RAN predicts early word recognition skills in Norwegian (Lervâg, Brâten, & Hulme, 2009), and reading speed in Italian (Di Filippo et al., 2006).

In our study, verbal working memory correlated weakly with nonword reading. Joubert and colleagues (2004) reported that silent reading of nonwords produced significantly increased activation in the left inferior prefrontal gyrus, which is the brain region linked to sublexical processes in reading such as grapheme-to-phoneme conversion, phoneme assembly, and underlying verbal working memory processes. Moreover, working memory (Cain, 2006; Seigneuric & Ehrlich, 2005), oral reading fluency (Petscher & Kim, 2011) and accuracy (Spooner, Baddeley, & Gathercole, 2004) have been shown to influence reading comprehension in children. We attribute the lack of such relationship in our study to the inadequate reading comprehension task we used (cf. Limitations section).

To sum up, the observed relations confirm the role of phonological awareness, RAN, and verbal working memory in reading in the semi-transparent Polish language. In our study, phonological awareness predicted the accuracy of reading aloud, while RAN – both accuracy and fluency (cf. Savage et al., 2005; Wagner & Torgesen, 1987). This further demonstrates the different role the two indices play at different stages of reading acquisition. RAN measures were not included in the original study by Krasowicz-Kupis (1999), which focused on explicit phonological

awareness skills. Our study showed that a dominance of a Global Strategy of reading in Polish includes a higher dependence on RAN. In older, advanced readers, the impact of RAN on real word reading should be even more conspicuous as compared with that of phonological awareness.

Besides the influence of developmental (person-related) and linguistic (the type of orthography, syntactic rules) aspects, also the didactic context might play an important role in reading acquisition. The types and frequency of errors committed by the participants in our study reflect the reading instruction model typically used in Polish schools, in which word decoding, sound and/or syllable segmentation and blending skills are trained (Dobkowska, 2014; Murawska, 2011). This is an effective teaching method to achieve technical proficiency in reading, as Polish has a relatively high transparency for reading (Awramiuk, 2006). However, analytic- synthetic methods should be complemented with a holistic approach, to promote interest to read (Dobkowska, 2014; Fijalkow, 2014; Murawska, 2011). An experiment in a year 3 class of an elementary school in Poland demonstrated that by creating their own schoolbooks, the children developed their meta-knowledge, meta-cognition, meta-learning, and self-awareness about their own production of culture, which facilitated learning competences (Uszyńska-Jarmoc & Żak, 2013).

Ehri (2011) noticed that a global word recognition reading strategy has been also demonstrated for orthographies more transparent than English, for example, Spanish and Portuguese (Defior, Martos, & Cary, 2002), and German (Wimmer & Goswami, 1994), in which decoding could be also applied. Our study confirms this strategy also in a semi-transparent writing system like Polish, corroborating Krasowicz-Kupis's theory (Awramiuk & Krasowicz-Kupis, 2014). We believe that the presented research provides material for possible comparative studies with other Slavic languages with similar phonological characteristics. It would be interesting to examine the possibility of the occurrence of analogical stages of reading acquisition (from the Analytical-Phonological to the Global one), the cognitive predictors of reading accuracy and fluency, and the nature of reading errors, following for example the methodology suggested by Caravolas and colleagues (2013) for English, Spanish, and Czech. Students' reading performance could be digitally recorded to later transcribe examples of errors to allow for a deeper analysis of the similarities and differences between languages. Moreover, cross-linguistic comparisons of the age of achieving subsequent reading stages could be conducted.

6. LIMITATIONS

The number of participants in our study was quite small for regression analyses, so these results must be interpreted tentatively. Therefore, we report both adjusted R^2 and R^2 indices. The task we used to measure reading comprehension consists only of 4 questions, which might have impacted calculations. However, this was the only task for this age group normalized for Polish population. We add new data to the already existing Polish studies of reading development. However, a longitudinal

study project examining the relationship between phonological processing and reading should be implemented in which a group of children should be followed from a pre-literacy stage (to examine the possibility of the occurrence of a logographic stage in reading) till adolescence.

7. CONCLUSIONS

Our results confirm the development of reading strategies from phonological-analytical to global in Polish, as suggested by Krasowicz-Kupis (Awramiuk & Krasowicz-Kupis, 2014). In the semi-transparent Polish orthography, since the beginning of reading instruction children develop their reading skills from sound blending, through syllable and morpheme blending, till word and phrase recognition strategies. This model of development is consistent with other alphabetical orthographies (Melby-Lervag et al., 2012).

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