L1-Educational Studies in Language and Literature

THE RELATIONSHIP BETWEEN THE IMPRESSIVE AND THE EXPRESSIVE COMPONENT OF WRITTEN SPEECH AND THE LEVEL OF EXECUTIVE FUNCTIONS IN CHILDREN AGED 3-11 YEARS

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Abstract

From the perspective of Lev S. Vygotsky's theory, literacy develops as a tool for executing the task of communicating with the use of script and this, in consequence, results in the development of a new higher mental function—written speech (WS). Both components of this function improve in parallel with acquisition of reading and writing: the impressive component (comprehending the meaning of a written text) and the expressive component (conveying meaning in a written form). These components reflect two directions of one process of communication and are like 'two sides of the same coin'. Reading and writing demand not only written speech activity but also activity of other mental functions, especially those necessary for planning and controlling behavior which are known as executive functions (EF). Little is found about how EF and two components of WS interact between the age of 3 and 11 when they develop quickly. The main research hypotheses are that (1) the relative dominance of the impressive and the expressive component of written speech is different across age groups, and that (2) the level of EF development is connected to patterns of dominance between the impressive and the expressive component of WS. A database from a previous cross-sectional study of 1103 healthy, Polish speaking children between the age of 3 and 11 was used for exploratory analysis of the EF-WS relationship. The subjects were examined with the use of the Literacy Assessment Battery and the paradigm of dimensional change card sort. The conducted analyses of the results confirmed both research hypotheses. Differences in the relative dominance of either the impressive or the expressive component of WS suggest that advances in the reading ability and in the writing ability cannot have the same dynamics. In turn, the level of EF development seems to predict the relation between both WS components most strongly in the age periods where the most dynamic progress in inhibitory control or cognitive flexibility takes place. Further longitudinal studies with a wider range of EF measures, which would give an opportunity to explore causal relations between EF and WS, could be promising, especially in view of identification of literacy development factors.

Keywords: written speech development, reading, writing, early literacy, executive functions.

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1. INTRODUCTION

Reading and writing are most frequently recognized as important academic skills, a good mastering of which is a ticket to further educational achievements and, in consequence, future life successes. However, when we take a closer look at these skills, we can see that being literate has, in fact, much deeper consequences. It could be even stated that thanks to reading and writing we become entirely different people. Why?

1.1. Effects of learning to read and write

First of all, for the reason that learning how to read and write, i.e., becoming literate, changes our brains. This has been confirmed by studies on illiterate people, in whom less cerebral lateralization of language functions is observed, and in whom a similar phenomenon is suspected to exist within the scope of visual-spatial functions in comparison to literate people (Ardila et al., 2010). Researchers also claim that with the use of adequate exercises it is possible to change the cerebral organization of reading (Shaywitz, & Shaywitz, 2004; Horowitz-Kraus, & Hutton, 2015) and that the sole process of learning how to use script changes the cerebral organization of other functions, e.g., visual perception (James, Jao, & Berninger, 2016).

Secondly, learning to read and write, i.e., learning to transcribe speech sounds with the use of graphic symbols, enables us to realize the rules governing the relationships between meanings and speech sounds and, in consequence, to have a greater control over speech. This regularity has been confirmed by studies on illiterate people, in whom difficulties in the phonological analysis of speech and processing nonsensical words (pseudo-words) were observed, along with a lowered level of metalinguistic awareness (Ardila et al., 2010).

Thirdly, literacy, being a communication tool, forces and, at the same time, facilitates organizing one's thoughts. Being a symbol of speech, a script simultaneously becomes a symbol of inner speech and a 'window' to verbal thinking. Thanks to the script we can 'see' our own thoughts, just like thanks to speech we can 'hear' them. From this perspective, in the development of literacy especially learning to write can be also understood as learning to better organize and express one's thoughts (Jabłoński, 2003).

Mastering the ability to read and write, we improve our earlier manner of functioning, also because—fourthly—we train the ability to take the perspective of other people. Shanahan (2016) in his review work mentions a number of studies in which the writer's audience awareness was proven to have an impact on the quality of the created text. Under experimental conditions, it has been shown that causing the writer's attention to focus on the perspective of the receiver of the written text improves, for example, persuasive writing, including greater inclusion of counterarguments.

And fifthly, becoming literate, we become autonomic individuals in terms of widening our knowledge because written text is a basic tool of acquiring new information.

The scope and complexity of consequences of becoming literate does not fit to the narrow image of reading and writing as merely two key academic skills. In order to conceptualize the process of becoming literate adequately to the effects of this process described above, it seems necessary to adopt a different perspective. Learning to read and write needs to be treated as a process of development of one specific and autonomous mental function, the basis of which is also a specific and autonomous cerebral system. Such an assumption can be found in the socio-cultural psychology of Lev S. Vygotsky.

1.2. Written speech as an important higher mental function

According to Vygotsky (1971, 1934/1997), along with mastering literacy skills, a new higher mental function and a new functional system, which constitutes its cerebral foundation, develop. The author calls this new mental function written speech (WS). Comparably to other higher mental functions, WS is characterized by, above all, the fact that it is a mental activity that uses signs. It is a very important trait, because by using signs the individual gains control over her/his own behavior (Veresov, 2010). Moreover, written speech uses signs that represent speech sounds. Therefore, it interacts with yet another higher mental function: oral speech, i.e., speaking, and through it, it also interacts with inner speech, i.e., verbal thinking (Jabłoński, 2002). It needs to be added that similarly to the case of oral speech, the basic purpose of WS is communicating with other people. This way the socio-cultural psychology of Lev S. Vygotsky creates a unified theoretical framework that enables studying all consequences of learning to read and write mentioned above.

The assumption about the development of a higher mental function during the course of learning the rules of reading and writing also makes it possible to capture all important factors of the development of human literacy. In the literature on the subject, the following factors are most frequently mentioned (especially with reference to literacy disorders): 1) cerebral foundations of reading and writing formed as a result of an interaction between biological and environmental factors, and 2) the level of functioning of the cognitive system. Much less frequently researchers investigate: 3) the quality of literacy environment at home, and 4) the quality of instruction (Hulme, & Snowling, 2013). In Lev S. Vygotsky's theory, we can find all of these factors, however in a slightly different depiction. According to this theory, in the development of written speech there intertwine both the natural (cerebral foundations) and the cultural (home environment, education) paths of development. For, Vygotsky assumed that higher mental functions have both a biological and a cultural genesis (Veresov, 2010). Moreover, the development of WS takes

place against the background of and in a close relationship with the development of the entire mental system (Jabłoński, 2002).

Naturally, the above juxtaposition of two perspectives on developmental factors has a general and approximate character. What has been omitted, are differences in defining the relationships between the mentioned groups of factors which are present between the socio-cultural approach and the cognitive approach that dominates contemporary studies on reading and writing. The characteristic of these differences goes beyond the scope of the present work, nevertheless, it is worth drawing attention to one of them. In the classic, cognitive approach, the influence of the factors mentioned above on the development of literacy is most frequently analyzed separately, as opposed to the socio-cultural approach.

1.3. The development of written speech

The socio-cultural approach to literacy enables us to analyze the course of development of reading and writing. From that perspective, these abilities are two components of WS associated with two directions of communicating with the use of script: 1) the impressive component of written speech (IWS)—receiving and comprehending the meaning of a written message (reading), and 2) the expressive component of written speech (EWS)—conveying meaning in and sending a written message (writing) (Jabłoński, 2002; Krasowicz-Kupis, 2008). The analysis of the development of WS requires analyzing these two components jointly, which makes it possible to track their mutual relationships in the process of development. The existence of such relationships has been postulated by a number of researchers (Frith, 1985; Snowling, 2000; Ehri, 2005). Some of them even pointed to the fact that an isolated analysis of the development of reading and writing may lead to serious errors in the interpretation of the obtained results (Paris, 2005; Devonshire, Morris, & Fluck, 2013). Despite that, as it has been summarized by Shanahan (2016), the developmental nature of reading and writing relationships has not attracted sufficient empirical attention. Therefore, it seems that the concept of written speech, in which reading and writing are inextricably connected to each other, has a chance to fill this gap.

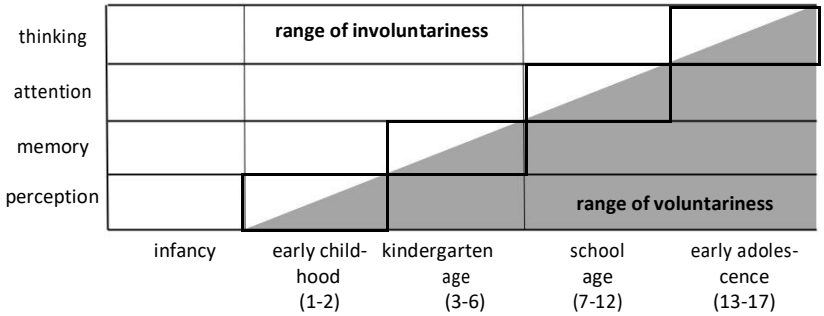
The character of the development of WS stems, in the first place, from the universal, four-stadium model of development of higher mental functions. A central criterion for distinguishing particular stadiums is in this model the manner of understanding the function of a sign (here: script in the process of communication). According to the model of WS development, we can distinguish the following stadiums: 1) natural, 2) naïve, 3) outer, and 4) inner. A brief specification of the four stadiums has been presented in Table 1 (for more details see: Jabłoński, 2002).

Table 1. Characteristics of the written speech development stadiums (source: Jabłoński & Kleka, 2015)

stadium	characteristics	components impressive form	expressive form
natural (NAT)	Children do not understand the meaning of writing and they treat it just like one of graphic forms, usually as a type of a picture.	– Writing is not distinguished from pictures – The aim and procedure of reading remain unknown (NATI)	– Acts of writing and reading are not differentiated from – The aim and procedure of writing remain unknown (NATE)
naïve (NAV)	Children tend to believe that every graphic shape made of writing symbols (e.g. letters) has a special name. To learn how to read or write, it is enough to remember the names of all words.	– All inscriptions (words) placed in the same graphic context (pictures) are deemed to be the same – All words that have a similar shape are recognized as the same ones (NAVI)	– Ability to copy words (NAVE)
outer (OUT)	Children discover that writing is a graphic description of speech sounds, so they can read aloud written texts and write spoken texts	– Words or texts are read aloud (OUTI)	– Words or texts are articulated while writing (OUTE)
inner (INT)	Children write and read „silently", as they are able to write without reproducing the sound form of the written text	– Silent reading – Texts are understood while reading (INTI)	– Silent writing – Texts of own conception are written correctly (INTE)

Secondly, the character of the development of written speech is also conditioned by the development of the mental system as a whole. In Vygotsky's theory, a central phenomenon in this development is increasing the scope of voluntariness at the level of mental functions and, in consequence, at the behavior level (Smykowski, 2012, p. 91). It refers to a gradual decrease of dependency of man's actions on internal (mental) and external (environmental) conditions and, as a result, an increase in the range of control over mental processes and behavior. Starting from early childhood, each consecutive stage of mental system development is determined by a new mental function that becomes at this very stage voluntary. For this reason, these functions become somewhat 'leaders' of the development in particular periods (see Figure 1).

Figure 1. Development of the mental system and the range of voluntariness



The range of voluntariness of perception, memory, attention and thinking during the particular developmental periods determines the available manner of understanding the function of script in the process of communicating, i.e., the possible stage of WS development. Due to the fact that written speech develops most intensively at the preschool and the school age, the greatest influence on its development should have the development of voluntariness of memory and attention.

1.4. Executive functions and the development of written speech

In contemporary studies, executive functions are the notion most consistent in terms of meaning with the issue of voluntariness (Fernyhough, 2009; Bodrova, Leong, & Akhutina, 2011). They can be identified with III functional block of the brain in the theory of Alexander R. Luria (1976, p. 92), which is responsible for programming, regulating and controlling mental activities. Needless to say, the foundations of Luria's neuropsychology were formulated in co-authorship with Vygotsky (Akhutina, 2003). Executive functions are "a collection of top-down control processes used when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible" (Diamond, 2013). Therefore, they enable acting independently of internal and external conditions, in other words, voluntarily.

When we juxtapose the development of executive functions and the development of written speech, it turns out that the two processes are characterized by a very high dynamics in two developmental periods: the preschool age and the school age. Strong links between the two processes of development were postulated by researchers who investigated the writing competence, emphasizing that it is based on self-regulation (Zimmerman, & Risemberg, 1997). MacArthur and Graham (2016) mention as many as 16 strategies for self-regulation in the writing process, behavior and writing environment (e.g. goal setting, planning, self-monitoring, self-evaluating, revising, etc.). Altemeier, Abbott, & Berninger (2008) point to the fact that executive functions play a leading role in the integration of visual and linguistic information and in the automatic retrieval of linguistic information from memory while learning to read. They observed that executive functions directly influence

literacy learning over the first four grades (of elementary school in the US). Also studies of the brain confirm the activity of neural circuits connected with executive functions during reading and writing (Horowitz-Kraus, & Hutton, 2015; James et al., 2016).

The above findings, concerning the relationship between the development of executive functions and the development of written speech, seem transparent from the perspective of Lev S. Vygotsky's theory. On the one hand, as it has been already mentioned above, the ability to use script in a given moment of the development process results from the developmental functioning of the entire mental system, particularly with respect to voluntariness and, at the same time, executive functions. Using the graphic signs of the script at initial stages of learning to read and write is not, for obvious reasons, an automatic action and it requires a high involvement of control processes. On the other hand, an intensive training in reading and writing, which the child undergoes at the preschool and the school age, is itself an opportunity for a frequent engagement of executive functions and it surely contributes to an increase in their efficiency.

The causative relationship of executive functions with the development of literacy has been confirmed by researchers of difficulties in reading. Individuals with deficits in working memory and inhibition experience difficulties in text comprehension and manifest inadequate inference making and comprehension monitoring. For, in order to comprehend a complex text, the reader has to extract from it and retain in memory the most important information, inhibiting, simultaneously, insignificant information. Also difficulties in a more compound executive function, planning and organizing, impede reading comprehension, particularly when the text is complex and long (for review see: Kendeou, van den Broek, Helder, & Karlsson, 2014). The most recent studies also indicate that the well-known effect of the relationship between SES and the level of reading skills can be intermediated by executive functions. Probably, developing in a specific kind of environment affects the development of executive functions that, in turn, provide particular abilities of acquiring reading skills (Corso, Cromley, Sperb, & Salles, 2016).

Studies presented in the following part of the current article have an exploratory character because, as mentioned earlier, so far there have been little works dedicated to the analysis of an interplay between the development of reading and writing, and even less to the analysis of this interaction in connection to executive functions. Limiting the studies presented here to exploratory purposes also results from the fact that these studies were realized within the framework of a wider research project with different objectives (see the author's note). The database obtained in such a way created an opportunity for conducting the preliminary exploratory study described below. Hence, the main objective of this study was to verify whether the relation between the level of development of the impressive (reading) and the expressive (writing) component of written speech is linked to the level of development of selected executive functions.

2. METHOD

Among executive functions that develop first and constitute the basis for the development of higher-order executive functions there are: inhibitory control, working memory and cognitive flexibility (Diamond, 2013). Since the relationship between working memory and reading and writing has been intensively studied (see for review: Alloway, & Copello, 2013; and MacArthur, & Graham, 2016), in the present article the measurement of executive functions pertains exclusively to inhibitory control and cognitive flexibility.

In studies conducted with the use of the same set of tools and on a sample of 3- to 5-year-old children, who were later added to the sample examined in this study, it has been established that the level of inhibitory control is connected to the level of written speech development (Jabłoński, 2013). At the same time, the level of executive functions and WS are connected to age (Diamond, 2013; Jabłoński, Kleka, 2015). For this reason, in the present studies the author focused on verifying whether the efficiency of the measured executive functions differentiates the relation of IWS to EWS in selected age groups.

The main aim of the presented research was to confirm that the relation between the level of development of the impressive (reading) and the expressive (writing) component of written speech: 1) is different depending on age, 2) is connected with inhibitory control, 3) is connected with cognitive flexibility.

2.1. Participants

The study is based on testing of 1103 children (553 girls and 550 boys) between the age of 3 years 0 months and 11 years 11 months (between 1080 and 4304 days of age; M = 2479.43; SD = 803.09). The majority of the children were recruited for the study in preschool institutions and at schools, mainly in Poznań and the surrounding area. In order to obtain a homogeneously diversified and representative sample in respect of age and gender, the children were recruited to 28 quarterly or half-year (two quarterly) gender groups. Thanks to this procedure, a satisfactory uniform distribution of the two variables in the investigated sample was obtained (see Table 2).

Table 2. Distribution of age and gender in the sample (source: Jabłoński & Kleka, 2015)

Girls (n=553)														
age group*	3 (n=57)				4 (n=68)				5 (n=69)				6 (n=108)	
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
size	8	17	16	16	15	15	22	16	18	16	19	16	18	28
age group*	6			7 (n=96)			8 (n=58)		9 (n=38)		10 (n=30)		11 (n=29)	
	III	IV	I	II	III	IV	I-II	III-IV	I-II	III-IV	I-II	III-IV	I-II	III-IV
size	32	30	23	21	27	25	23	35	17	21	16	14	14	15
Boys (n=550)														
age group*	3 (n=68)				4 (n=68)				5 (n=64)				6 (n=101)	
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
size	15	17	21	15	15	22	16	15	11	19	18	16	21	21
age group	6			7 (n=98)			8 (n=51)		9 (n=40)		10 (n=30)		11 (n=30)	
	III	IV	I	II	III	IV	I-II	III-IV	I-II	III-IV	I-II	III-IV	I-II	III-IV
size	27	32	20	24	26	28	23	28	19	21	12	18	15	15
Total (n=1103)														
age group*	3 (n=125)				4 (n=136)				5 (n=133)				6 (n=209)	
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II
size	23	34	37	31	30	37	38	31	29	35	37	32	39	49
age group*	6			7 (n=194)			8 (n=109)		9 (n=78)		10 (n=60)		11 (n=59)	
	III	IV	I	II	III	IV	I-II	III-IV	I-II	III-IV	I-II	III-IV	I-II	III-IV
size	59	62	43	45	53	53	46	63	36	42	28	32	29	30

* Age of children is described by Arabic numbers (years) and Roman numbers (quarters of the year).

Other parameters of sampling were not controlled for (e.g. random sampling of schools), because it was not necessary for the main project within the framework of which the research sample had been recruited (see the author's note). For this reason, the obtained distribution of the parents' education level is not representative for the Polish population (see Table 3).

Table 3. Level of parents' education in the sample

	basic	vocational	upper	higher	not reported
mothers	1.45% (16)	9.16% (101)	28.65% (316)	5.93% (661)	0.82% (9)
fathers	1.00% (11)	19.50% (215)	31.37% (346)	45.87% (506)	2.27% (25)

2.2. Procedure

The study was a part of a project under which every child participated in two ca. 40-minutes-long research sessions (see the author's note), conducted with at least one-day break. In the analysis presented here, the results of every child from the first session (realized between June of 2012 and February of 2014) were used. The examinations were conducted by specially trained researchers, who had previous experience in working with children. Before the study, the children's parents received a form that included detailed information about the course of the examination procedure, on which they would express voluntary and informed consent for the participation of their child in the study. The consent was expressed in the case of 1350 healthy children. The results of one child, who at the moment of the study was not 3 yet, were not taken into consideration. Every child in the case of whom the parent's consent was obtained, both before and during the procedure, was asked whether s/he wanted to take part in the study. When the answer was negative, the study would be stopped. The examination of each child was conducted during an individual meeting with the researcher, in a quiet place that made it possible for the child to work efficiently.

2.3. Materials

During the study, the children would first do the Children Card Sort (CCS), and subsequently the Literacy Assessment Battery (LAB). Both of these methods are characterized by a satisfactory level of validity and reliability. Reliability of the CCS, estimated with the use of Guttman's lambda-6, was .73-.95. Construct validity of the tool was confirmed in factor analysis and in a comparison of the results achieved by healthy children and children with specific language impairment. Criterion validity was confirmed in a significant correlation with the age (r = .12-.66; N = 512 for girls and r = .13-.55, N = 526 for boys), and in a correlation with the result of the Raven's Progressive Matrices (r = .18-.62, N = 512 for girls and r = .17-.52; N = 527 for boys) (Jabłoński, Kaczmarek, Kleka, in press).

In the case of the LAB method, reliability estimated with the use of Guttman's lambda-6 was lower for two variables (.58 for PPD and .62 for DWD, see Table 4 for explanation of abbreviations), whereas for the remaining variables it oscillated between .92 and .98. Validity of the tool was corroborated in confirmatory factor analysis ($\chi^2(105) = 3102$, $p < .001$; CFI = .96; TLI = .94; SRMR = .049; RMSEA = .060

[90%CI .05—.07], p = .042), in correlations with the age (the correlation median was .63, N = 1000), and in correlations with the result of the Raven's Progressive Matrices (the correlation median was r = .60, N = 1000). One variable (COH) correlated neither with the age nor the result of the Raven's Progressive Matrices (Jabłoński, Kleka, in press).

2.3.1. Children Card Sort

The Children Card Sort was devised on the basis of two parallel versions of Dimensional Change Card Sort (DCCS): standard, designed for younger children, and advanced, for older children (Zelazo, 2006; Jabłoński, 2013). The CCS differs from both of these versions with respect to the application area, the type of stimuli and procedure, but it preserves the general sense of their construction. For, as opposed to the DCCS, the CCS is a method of conducting an individual diagnosis of executive functions, in which the order of presentation of cards is strictly defined. The content of the cards was adapted to the Polish cultural reality.

The examination with the use of the CCS consists in sorting by the child 28 cards, and it is composed of four phases. During the demonstration (phase I), the researcher would explain to the child the procedure of the study and ask the child to perform a trial sorting of two cards. In consecutive stages of the study (phase II and III), the researcher would show particular cards to the child, reminding each time about the sorting rule. In phase II the child would sort 7 cards according to the color, and in the next phase another 7 cards according to the shape. After phase III was finished, the researcher would inform the child about a new rule of sorting the remaining 12 cards, connected with the appearance of a frame on the cards. The child should sort the cards with the frame according to the color and the cards without the frame according to the shape. The researcher would not inform the child during the study about the correctness of her/his answers. The result obtained in phase III (minimum 0, maximum 7 points) marks the level of development of inhibitory control. This function, in the form measured by the CCS test, develops between the age of 3 and 5 (Zelazo, 2006). The result obtained in phase IV marks the level of development of cognitive flexibility (minimum 0, maximum 12 points). In the form measured by the sorting cards test, cognitive flexibility starts to develop at the age of ca. 7 (Zelazo, 2006).

When interpreting the results of the CCS, we have to bear in mind that there is no unanimous stance among researchers about what this test precisely measures. A high number of correct answers in the CCS may indicate both a high and a low level of inhibitory control, as well as of the level of working memory, perspective taking or ability to represent complex rules (Halford, Wilson, & Phillips, 1998; Kloo, Perner, Aichhorn, & Schmidhuber, 2010; Zelazo et al., 2003). For this reason, in the present article the CCS will be used as a measure of inhibitory control and cognitive flexibility only on the behavioral level.

2.3.2. Literacy Assessment Battery

The Literacy Assessment Battery (LAB) was devised on the basis of the model of written speech development proposed by the author (Jabłoński, 2002). It includes 9 tasks designed to investigate the two components of written speech during the particular stadiums of its development (see Table 4). Each of the fifteen variables measured by the LAB comes from a set of key characteristics of reading and writing that enable the identification of the stadium of WS development. Particular tasks are, for the most part, ordered by the level of difficulty, from the easiest one to the most difficult one, and in such sequence they would be presented to the investigated children.

The investigated individuals would not be informed about the correctness of their answers during the study. The raw score of the LAB procedure was calculated separately for each variable. The score equalled the number of points gained for each item in the task connected with the given variable. Next, the raw score was transformed into the percentage of the theoretical maximal score for the particular variable, in order to gain easy orientation in the level of the results for the particular variables, especially the relationship between the level of impressive and expressive component of written speech (see below). The criteria of performance assessment in particular tasks were designed in such a way that the higher the obtained value of the variable, the higher the level of development of written speech within the scope of the measured variable. Due to the expected high diversification of the level of written speech among the children from the same age groups (see Jabłoński, 2013), all children were examined with the use of the entire battery, regardless of the correctness of their answers.

Table 4. Design of the Literacy Assessment Battery (for stage reference see Table 1) (source: Jabłoński, 2013)

Tool no.	Tool name	Characteristics of the task	Aids	Variable symbol and stage reference	Variable name
1	What is it (reading)?	Subject answers two questions: *What is that (print)? What for people read?* and follows one instruction: *Please show me how to read*.	A chart with an illustrated tale	PPD (NATI)	Picture-print discrimination
2	What is it (writing)?	Subject answers three questions: W*hat am I doing (drawing)? What am I doing (writing)? What for people write?* and follows one instruction: *Please show me how to write*.		DWD (NATE)	Drawing-writing discrimination
3	Find the same word	Subject points the word (name of the object illustrated in the picture) identical with the pattern	5 charts with pictures, each with 1 pattern and 5 pictures with names, some names do not match the objects presented in the pictures	VRN (NAVI)	Visual recognition of the names of the objects presented in the pictures
4	Compare words	Subject is supposed to state whether the two words that s/he sees are identical or different	5 series of cards with single words, in each series there is one card with a word-pattern and 4-5 cards with words to be compared with the pattern	DOW (NAVI)	Discrimination of words
5	Write a word	Subjects writes down on a piece of paper 3 consecutive words s/he hears using a chart	A chart with pictures and words-names, none of the included names matches the presented pictures, but the name of each object is presented on the chart	ONW (NAVI) COW (NAVE)	Object names writing Copying words
6	Read a word	Subject reads a word and after a while answers the question: *What was this word?*	6 cards with single words	WOR (OUTI) MOR (OUTI)	Words reading Manner of reading
7	Write a sentence	Subject writes down on a piece of paper the sentence s/he hears	A card with 3 sentences to be read to the subject	MOW (OUTE) SEW (OUTE)	Manner of writing Sentences writing
8	Split into sentences	Subject marks the end of each sentence, placing there a dot	A card with a short story, sentences do not start with capital letters and do not end with dots	RCO (INTI) RRT (INTI)	Reading comprehension Reading rate
9	Write a story	Subject writes down constructed by her- himself sentences	A chart with 4 pictures creating a picture story	GRA (INTE) SYN (INTE) COH (INTE)	Grammar Syntax Coherence

3. RESULTS

The procedure of examining the children from all age groups with the use of the entire battery allowed identifying children not only with a level of speech development typical for the particular age, but also children with unusually high or low level of WS development. Unfortunately, applying such a scheme of studies resulted also in the fact that for some children a part of the tasks from the battery turned out to be either too easy or too difficult (e.g. in the group of children between the age of 4 years 9 months and 4 years 11 months N = 31 none of the children completed task 9). In order to avoid difficulties in the statistical analysis, resulting from too low diversification of the results, it was conducted with the observation of indicators of written speech development which were separate for each stadium of development. These indicators took the form of additional variables, and their values were arithmetical means of respective primary variables (see Table 5). The theoretical range of the primary and the additional variables was, therefore, between 0 (the minimum value) and 1 (the maximum value).

Table 5. Additional variables for the LAB

basic variable	additional variable name	symbol
PPD, VRN, DOW, ONW	IMpressive aspect of written speech (reading) in NAïve stage	IMNA
WOR, MOR	IMpressive aspect of written speech (reading) in OUter stage	IMOU
RCO, RRT	IMpressive aspect of written speech (reading) in INner stage	IMIN
DWD, COW	EXpressive aspect of written speech (reading) in NAive stage	EXNA
MOW, SEW	EXpressive aspect of written speech (reading) in OUter stage	EXOU
GRA, SYN, COH	EXpressive aspect of written speech (reading) in INner stage	EXIN

The statistical analysis of the results was conducted with the use of non-parametric methods due to non-normal distribution of all of the investigated variables. To statistically verify differences between the age groups with respect to the relation between the level of IWS and the level of EWS at every stage of the development, two analyses were conducted. In the first one, the results obtained by particular age groups were compared separately for every additional variable (listed in Table 5). In order to do so, Kruskal-Wallis tests with post-hoc Dunn test with Bonferroni correction for multiple comparisons were applied. The second analysis consisted in comparing the level of IWS and EWS in every age group, separately for every stadium of WS development. In this analysis, Wilcoxon signed rank tests for related samples were applied.

In order to verify whether the relation between the level of development of the impressive (reading) and the expressive (writing) component of written speech is connected to the level of executive functions, the author conducted an analysis of the level of inhibitory control and cognitive flexibility in groups established on the basis of one of the three types of IWS-EWS relations (i.e. higher IWS than EWS, higher EWS than IWS, EWS equal to IWS) and age. The analysis was conducted with the use of Kruskal-Wallis tests with post-hoc Dunn test with Bonferroni correction for multiple comparisons. All of the above analyses were conducted with the use of IBM SPSS Statistics, Version 24.

3.1. Impressive and expressive components of written speech in age groups

The first hypothesis tested in the present research was that the relation between the level of development of the impressive (reading) and the expressive (writing) component of written speech is different depending on age. In order to verify this hypothesis, a comparison of IWS and EWS in the age groups was conducted separately for every stadium of WS development.

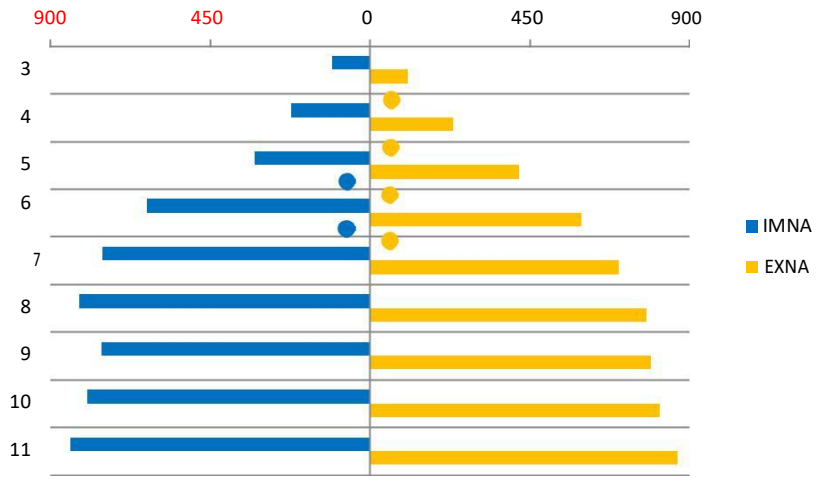
Table 6. Effect size (η^2) for IMNA and EXNA comparisons between the age groups and significance by Dunn test with Bonferroni correction for multiple comparisons.

age in years	3	4	5	6	7	8	9	10	11
					η^2 for IMNA				
3	-	-.10	-.20***	-.47***	-.59***	-.65***	-.59***	-.62***	-.67***
4	-.12*	-	-.09	-.37***	-.48***	-.54***	-.48***	-.52***	-.56***
5	-.28***	-.17***	-	-.28***	-.39***	-.45***	-.39***	-.43***	-.47***
6	-.44***	-.33***	-.16***	-	-.11**	-.17***	-.12	-.15**	-.20***
7	-.54***	-.42***	-.26***	-.10*	-	-.06	-.00	-.04	-.08
8	-.61***	-.49***	-.33***	-.17***	-.07	-	-.06	-.02	-.02
9	-.62***	-.51***	-.34***	-.18***	-.08	-.01	-	-.04	-.08
10	-.64***	-.53***	-.36***	-.20***	-.10	-.03	-.02	-	-.04
11	-.69***	-.57***	-.41***	-.25***	-.15*	-.08	-.07	-.05	-
					η^2 for EXNA				

*$p < .05$, **$p \leq .01$, ***$p \leq .001$

In the naïve stadium of WS development the impressive component of written speech turned out to be linked to age to an average extent (Kruskal-Wallis H = 755.22, p < .001, N = 1103, effect size: ε^2 = .69) and it had a three-step distribution in the investigated sample. The group composed of the 3-, 4- and 5-year-olds was characterized by the lowest level of IMNA (see Table 5 for explanation of abbreviations), the group of the 6-year-olds—an average, and the group of the 7-year-olds and older had the highest level of IMNA (see Table 6 and Figure 2).

Figure 2. Distribution of the mean ranks for IMNA and EXNA in the age groups (significant differences between 'neighboring' age groups for IMNA are marked by blue dots and for EXNA by yellow dots)



The expressive component in this stadium of WS development was also linked to age to an average extent (Kruskal-Wallis $H = 670.52$, $p < .001$, N = 1103, effect size: $\varepsilon^2 = .61$). EXNA had a five-step distribution in the examined sample. Each of the four consecutive age groups in the range between 3 and 6 years of age was characterized by a higher level of EXNA. The highest results obtained the children from the group that included five age groups: from 7- to 11-year-olds.

The analysis of the relations between IMNA and EXNA in the investigated sample showed that the majority of the age groups obtained higher results for IMNA than for EXNA, except for the 5-year-olds, who obtained the opposite results (see Table 7).

In the outer stadium of WS development the impressive component of written speech was to an average extent linked to age (Kruskal-Wallis $H = 606.22$, $p < .001$, N = 1002, effect size: $\varepsilon^2 = .61$) and it had a four-step distribution in the investigated sample: from the lowest to the highest level of IMOU. The group composed of the 3-, 4- and 5-year-olds was characterized by the lowest level of IMOU (step one), the group of the 6-year-olds—a higher level than previous group (step 2), the group of the 7-year-olds—a higher level than previous group (step 3), whereas the group composed of the 8-year-olds and older children—the highest level of IMOU (step 4) (see Table 8 and Figure 3).

Table 7. Standardized differences (Z) between IWS and EWS within the age groups and significance by related samples Wilcoxon signed rank test (negative results means that level of IWS is higher than level of EWS) and groups formed regarding IWS-EWS relation

age in years	3	4	5	6	7	8	9	10	11
					Z				
EXNA-IMNA	-7.36***	-4.34***	2.72***	-3.71***	-7.57***	-4.62***	-2.33*	-3.06**	-3.12**
EXOU-IMOU	2.43*	2.92**	-2.04*	-2.18*	1.82	8.26***	6.99***	6.81***	6.95***
EXIN-IMIN	-	-	1.21	3.90***	2.23*	-2.22*	-5.75***	-6.02***	-6.66***
					group's code and age group reference				
EXNA-IMNA	1A	1A	2A	3A	3A	3A	3A	3A	3A
EXOU-IMOU	1B	1B	2B	2B	3B	4B	4B	4B	4B
EXIN-IMIN	-	-	1C	2C	2C	3C	3C	3C	3C

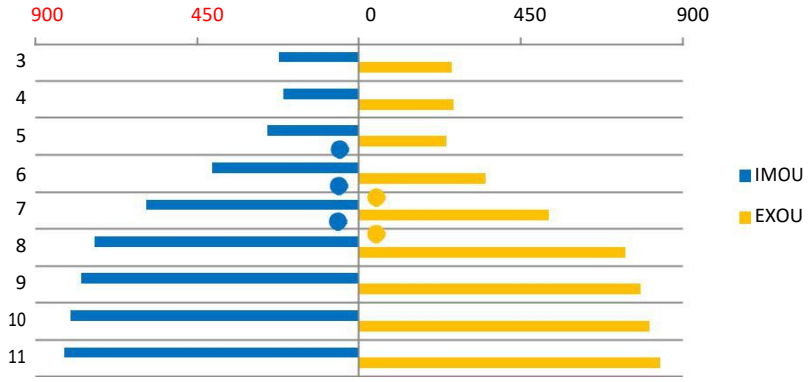
*$p < .05$, **$p \leq .01$,***$p \leq .001$

Table 8. Effect size (η^2) for IMOU and EXOU comparisons between the age groups and significance by Dunn test with Bonferroni correction for multiple comparisons

age in years	3	4	5	6	7	8	9	10	11
					η^2 for IMOU				
3	-	-.01	-.03	-.17***	-.34***	-.47***	-.50***	-.53***	-.54***
4	-.00	-	-.04	-.18***	-.35***	-.48***	-.51***	-.54***	-.55***
5	-.01	-.02	-	-.14***	-.31***	-.44***	-.47***	-.50***	-.51***
6	-.08	-.08	-.10	-	-.17***	-.30***	-.33***	-.36***	-.37***
7	-.24***	-.24***	-.26***	-.16***	-	-.13***	-.16***	-.19***	-.21***
8	-.44***	-.43***	-.45***	-.35***	-.19***	-	-.03	-.06	-.08
9	-.48***	-.47***	-.49***	-.39***	-.23***	-.04	-	-.03	-.04
10	-.50***	-.50***	-.51***	-.42***	-.26***	-.06	-.02	-	-.02
11	-.53***	-.52***	-.54***	-.44***	-.28***	-.09	-.05	-.03	-
					η^2 for EXOU				

***$p \leq .001$

Figure 3. Distribution of the mean ranks for IMOU and EXOU in the age groups (significant differences between 'neighboring' age groups for IMOU are marked by blue dots and for EXOU by yellow dots)



The expressive component in this stadium of WS development also turned out to be connected to age on an average level (Kruskal-Wallis H = 588.48, p < .001, N = 984, effect size: ε^2 = .60). EXOU had a three-step distribution in the examined sample. The children between the age of 3 and 6 were characterized by the lowest level of EXOU, whereas the 7-year-olds by an average level. The highest results obtained the children from the group that included four age groups: from 8- to 11-year-olds.

The analysis of the relations between IMOU and EXOU in the investigated sample showed that the majority of the age groups obtained higher results for EXOU than for IMOU, except for the 5- and 6-year-olds, who obtained the opposite results, and for the 7-year-olds, whose results for both variables were equal (see Table 7).

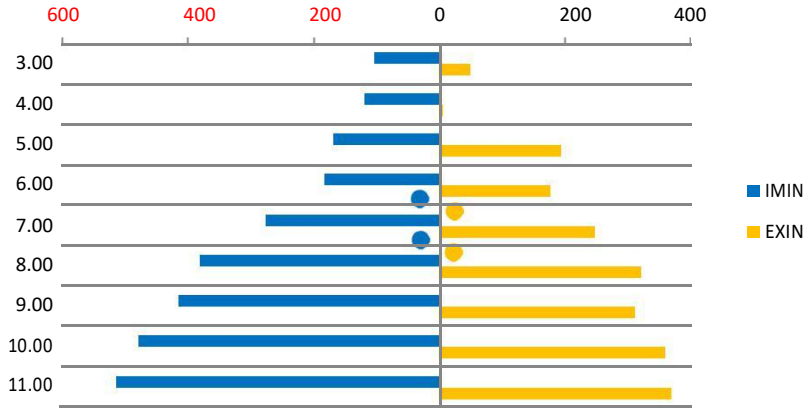
Table 9. Effect size (η^2) for IMIN and EXIN comparisons between the age groups and significance by Dunn test with Bonferroni correction for multiple comparisons

age in years	3	4	5	6	7	8	9	10	11
					η^2 for IMIN				
3	-	-.01	-.06	-.07	-.16	-.25*	-.28**	-.34***	-.37***
4	-.04	-	-.05	-.06	-.14**	-.24***	-.27***	-.33***	-.36***
5	-.13	-.17	-	-.01	-.10	-.19***	-.22***	-.28***	-.31***
6	-.12	-.16	-.01	-	-.08***	-.18***	-.21***	-.27***	-.30***
7	-.18	-.22	-.05	-.06*	-	-.10***	-.13***	-.18***	-.22***
8	-.25	-.29	-.12	-.13***	-.07*	-	-.03	-.09*	-.12***
9	-.24	-.28	-.11	-.12***	-.06	-.01	-	-.06	-.09
10	-.28	-.32	-.15	-.16***	-.10***	-.03	-.04	-	-.03
11	-.29	-.33	-.16*	-.17***	-.11***	-.04	-.05	-.01	-
					η^2 for EXIN				

*p < .05, **p ≤ .01, ***p ≤ .001

In the inner stadium of WS development the impressive component of written speech was linked to age to an average extent (Kruskal-Wallis $H = 260.11$, $p < .001$, N = 646, effect size: $\varepsilon^2 = .40$) and it had a three-step distribution in the investigated sample. The group composed of the children between the age of 3 and 6 was characterized by the lowest level of IMIN, the group of the 7-year-olds—an average, and the group composed of the 8-year-olds and older children—the highest level of IMIN (see Table 9 and Figure 4).

Figure 4. Distribution of the mean ranks for IMIN and EXIN in the age groups (significant differences between 'neighboring' age groups for IMIN are marked by blue dots and for EXIN by yellow dots)



The expressive component in this stadium of WS development turned out to be linked to age to a low extent (Kruskal-Wallis $H = 92.94$, $p < .001$, N = 564, effect size: $\varepsilon^2 = .17$). EXIN had a three-step distribution in the investigated sample. The children aged 3-6 were characterized by the lowest level of EXIN, whereas the 7-year-olds—an average. The highest results obtained the children from the group composed of four age groups: from 8- to 11-year-olds.

The groups of the 3- and 4-year-olds were excluded from the analysis of IMIN-EXIN relation due to the small number of children who obtained results for the IMIN and EXIN variables. The analysis of the relation between IMIN and EXIN in the examined sample showed that the group composed of the 5-year-olds obtained equal results for the two components of WS, in the 6- and 7-year-olds EXIN was higher, whereas in the case of the 8-year-olds and older children IMIN was higher than EXIN (see Table 7).

The comparison of the levels of IWS and EWS in different stadiums of written speech development allows making the observation that they differ across age groups. Moreover, the obtained distribution of differences in particular age groups

implicates that reading and writing do not develop completely in parallel to one another.

3.2. Executive functions and the two components of written speech

In order to verify whether the level of development of executive functions is connected to a specific type of relations between the impressive and the expressive component of WS, the investigated groups of children were assigned to new groups established on the basis of the Wilcoxon's test results, separately for every stage of WS development. The type of relation between IWS and EWS (i.e. IWS>EWS, IWS=EWS or IWS<EWS) and the order of the age groups (only 'neighboring' groups were joined) were taken into consideration. As a result, the author obtained 3 groups for the naïve stadium of WS (labeled 1A-3A), 4 groups for the outer stadium of WS (labeled 1B-4B) and 3 groups for the inner stadium of WS (labeled 1C-3C) (see Table 7). Next, a comparison of the level of inhibitory control and cognitive flexibility was conducted in the established groups. Non-parametric tests were applied here due to the character of distribution of the investigated variables (see Table 10).

Table 10. Descriptive statistics for executive functions in groups formed regarding IWS-EWS relation

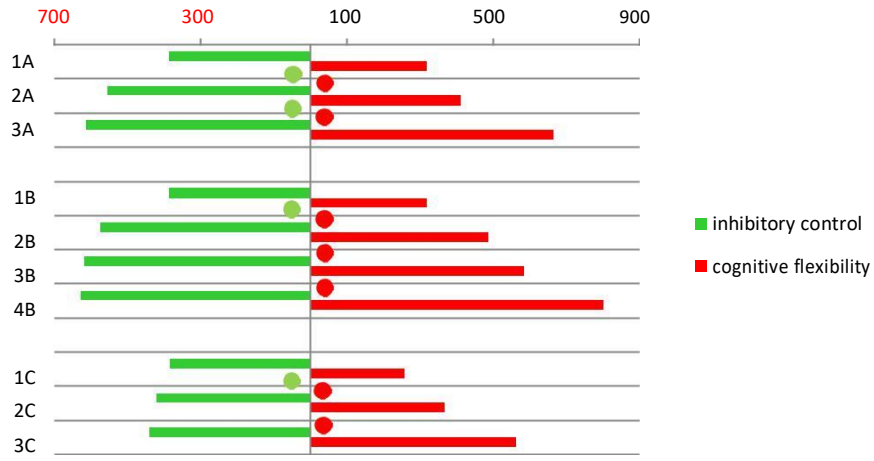
Group	N	Inhibitory control				Cognitive flexibility			
		Range	*M (SD)*	Skew	Kurtosis	Range	*M (SD)*	Skew	Kurtosis
1A or 1B	261	0-7	4.95 (2.81)	-.97	-.80	2-12	7.14 (1.41)	.36	2.08
2A or 1C	133	0-7	6.59 (1.23)	-4.10	18.05	4-12	7.83 (1.80)	.84	.07
3A	709	0-7	6.88 (.59)	-8.20	83.91	1-12	9.57 (2.19)	-.61	-.30
2B	342	0-7	6.69 (1.08)	-4.75	24.69	4-12	8.35 (2.04)	.37	-.79
3B	194	5-7	6.93 (.31)	-4.72	23.11	1-12	8.97 (2.19)	-.47	.41
4B or 3C	306	5-7	6.95 (.26)	-5.78	35.47	3-12	1.57 (1.79)	-1.49	2.13
2C	403	0-7	6.83 (.74)	-6.81	55.14	1-12	8.81 (2.15)	-.19	-.33

The highest diversification of the level of inhibitory control could be observed in the case of the naïve stadium of WS development. The degree of connection of inhibitory control with the type of relation between IMNA and EXNA turned out to be, as a matter of fact, low (Kruskal-Wallis H = 225.49, p < .001, N = 1103, effect size: ε^2 = .20), nevertheless, all of the compared groups differed in this respect. The group 1A (IMNA>EXNA, age: 3-4) was characterized by a lower, the group 2A (IM-

NA<EXNA, age: 5) by an average, and the group 3A (IMNA>EXNA, age 6-11) by an upper level of inhibitory control (see Table 11 and Figure 5).

In the outer stadium of WS, a difference in the level of inhibitory control could be observed only in the case of the youngest and the older groups of children. The group 1B (IMOU<EXOU, age: 3-4) was characterized by a lower level of inhibitory control, whereas the group composed of the groups 2B (IMOU>EXOU, age 5-6), 3B (IMOU=EXOU, age 7) and 4B (IMOU<EXOU, age: 8-11) manifested a higher level of inhibitory control (see Table 11 and Figure 5). The degree of connection of inhibitory control with the type of IMOU-EXOU relations turned out to be comparably low as in the naïve stadium (Kruskal-Wallis $H = 227.80$, $p < .001$, N = 1103, effect size: $\varepsilon^2 = .21$).

Figure 5. Distribution of the mean ranks for inhibitory control and cognitive flexibility in the groups formed regarding IWS-EWS relation (significant differences between 'neighboring' groups for inhibitory control are marked by green dots and for cognitive flexibility by red dots)



In the inner stadium of WS, the degree of diversification of the level of inhibitory control was similar to the outer stadium, however, the link between the level of inhibitory control and the type of relation between IMIN and EXIN turned out to be much lower (Kruskal-Wallis $H = 22.61$, $p < .001$, N = 842, effect size: $\varepsilon^2 = .03$). The compared groups can be divided into groups characterized by a lower (group 1C, IMIN=EXIN, age: 5) and a higher level of inhibitory control (group 2C, IMIN<EXIN, age: 6-7 and group 3C, IMIN>EXIN, age: 8-11) (see Table 11 and Figure 5).

Table 11. Effect size (η^2) for inhibitory control and cognitive flexibility comparisons between the groups formed regarding IWS-EWS relation and significance by Dunn test with Bonferroni correction for multiple comparisons

Group											
	1A	2A	3A		1B	2B	3B	4B		1C	2C	3C
						η^2 for inhibitory control						
1A	-	-.15***	-.21***	1B	-	-.17***	-.21***	-.22***	1C	-	-.04**	-.07***
2A	-.08*	-	-.05**	2B	-.15***	-	-.04	-.05*	2C	-.13***	-	-.02
3A	-.31***	-.23***	-	3B	-.24***	-.09**	-	-.01	3C	-.36***	-.23***	-
				4B	-.44***	-.29***	-.20***	-				
						η^2 for cognitive flexibility						

*$p < .05$, **$p \leq .01$, ***$p \leq .001$

The obtained results made it possible to establish that in the groups created on the basis of the type of relation between the impressive and the expressive component of written speech the level of inhibitory control differs. These differences most often pertain to the younger groups of children (3-5 years of age) in comparison with the groups of older children (aged 6-11). The diversification within the type of IWS-EWS relation in the younger groups overlaps, therefore, with the period of an intensive development of inhibitory control, especially in the scope measured by the Children Card Sort. It is also worth noting that the degree of connection of the level of inhibitory control with the type of IWS-EWS relation is the highest for the naïve and outer stadium, which indicates that the importance of this executive function is much higher in the first two stadiums of WS development. The level of cognitive flexibility turned out to be weakly connected to the type of relation between IWS and EWS, both in the naïve stadium (Kruskal-Wallis $H = 259.73$, $p < .001$, N = 1103, effect size: $\varepsilon^2 = .24$), the outer stadium (Kruskal-Wallis $H = 353.85$, $p < .001$, N = 1103, effect size: $\varepsilon^2 = .32$) and in the inner stadium of WS (Kruskal-Wallis $H = 190.14$, $p < .001$, N = 842, effect size: $\varepsilon^2 = .23$). Nonetheless, it is worth noting that the effect size is the highest for the outer stadium, which may suggest a stronger connection between cognitive flexibility and this stadium of written speech development. If we take into consideration the fact that the outer stadium is characteristic of the children aged 6-8 in the investigated sample (see Jabłoński, 2015), it turns out that the effect size is the highest in the period of the most intensive development of cognitive control in the scope measured by the CCS.

As opposed to inhibitory control, the level of cognitive flexibility differentiates all of the investigated groups in every of the three stadiums of WS. In the naïve stadium, the lowest level of cognitive flexibility was characteristic of the group 1A (IMNA>EXNA, age: 3-4), the group labeled 2A had an average level of cognitive flexibility (IMNA<EXNA, age: 5), whereas the group 3A (IMNA>EXNA, age 6-11) manifested the highest level of this function (see Table 11 and Figure 5).

In the outer stadium, the lowest level of cognitive flexibility could be observed in the group 1B (IMOU<EXOU, age: 3-4), in the group 2B (IMOU>EXOU, age 5-6)—a higher level than in previous group, in the group 3B (IMOU=EXOU, age 7)—a higher level than in previous group and the highest in the group 4B (IMOU<EXOU, age: 8-11) (see Table 11 and Figure 5).

And finally, in the inner stadium, the lowest level of cognitive flexibility could be observed in the group 1C (IMIN=EXIN, age: 5), an average in the group 2C (IMIN<EXIN, age: 6-7) and the highest level in the group 3C (IMIN>EXIN, age: 8-11) (see Table 11 and Figure 5).

On the basis of the conducted analyses, it can be stated that the hypothesis about the relationship between the level of executive functions and the type of relation between the impressive and the expressive component of WS has been confirmed.

4. DISCUSSION

The main aim of the studies presented in this article was to confirm that the relation between the level of development of the impressive (reading) and the expressive (writing) component of written speech: 1) differs depending on age, 2) is connected with inhibitory control, 3) is connected with cognitive flexibility.

On the basis of the obtained results, it can be stated that the hypothesis about the changing relation between IWS and EWS in the course of development was confirmed. The comparison of this relation in the particular stadiums of WS development showed that it is different in different age groups and in different stadiums of WS development. In the investigated sample, a specific configuration of IWS-EWS relations in age groups was obtained for every stadium of WS development. In the naïve stadium of WS, the impressive component of written speech is most frequently developed on a higher level than the expressive component, except for the 5-year-olds in the case of whom we can observe IWS<EWS. Taking into consideration the fact that the 5-year-olds differ from the 4-year-olds in the level of EXNA, but they do not differ in respect of the level of IMNA, we can hypothesize that the main reason behind the change of the IWS-EWS relation at this age is the change of the level of EXNA. In the outer stadium, the majority of the age groups are characterized by the relation IWS<EWS, except for the group of the 5-, 6- and 7-year-olds. Also in the case of this stadium we can formulate a hypothesis that what is crucial for these groups, is an increase of both IWS and EWS at the age of 4-5 and 6-8, as well as an increase of IWS in the period between the age of 5 and 6. In the inner stadium, the majority of the investigated age groups are characterized by the relation IWS>EWS. Only in the group of the 5-, 6- and 7-year-olds this relation is different. Hypothetically, a considerable increase with respect to both IWS and EWS that takes place between the age of 6 and 7 and between the age of 7 and 8 can be of significance here. Both the results obtained by the author and the above hypothesis are consistent with the suggestions of Frith (1985) and Ehri (2005), who emphasize that advances in the reading ability and in the writing ability do not have the same dynamics, and that changes in one ability can induce changes in the other ability. Of course, in order to analyze these dependencies in detail, it is necessary to conduct longitudinal studies and not cross-sectional, as it was the case of the research reported in this paper.

The comparison of the impressive and the expressive component of WS should be also analyzed in the broader context of environmental influences on WS development. Shanahan (2016, p. 203) observes that „everything that is known about reading-writing relations has been learned in the context of instruction that prioritizes reading over writing". In this light, it seems necessary to conduct further studies that would allow the verification of conditions of the observed relationships between reading and writing. For it needs to be determined, in the first place, to what degree the character of these relations results from the universal dynamics of the development of written speech as a higher-order mental function. Secondly, it

needs to be answered what influence has on them the IWS/EWS proportion in the environment, e.g., how much time is devoted to learning to read and to learning to write in kindergartens and at schools, but also under practices that support the child's development applied by parents at home.

The obtained results confirm that the level of executive functions is connected to the relation between the impressive and the expressive component of WS. On the basis of the statistical analysis of the results, it has been also established that the level of inhibitory control differentiates the most the IWS-EWS relation in the naïve stadium of WS, and that the level of cognitive flexibility seems to be the most significant for this relation in the outer stadium of WS. Therefore, in both cases, the differences in the IWS-EWS relation can be observed in the periods of an intensive development of each of these executive functions. This result is consistent with postulates of some researchers, for example, Altemeier et al. (2008), about the necessity to distinguish between a lower and a higher level of executive functions, engaged at different stages of literacy development (Altemeier et al., 2008; Christopher, 2012). For inhibitory control, which belongs to basic executive functions, turned out to be important for the relation between reading and writing in the early stadium of WS development. In turn, cognitive flexibility, an executive function more advanced than inhibitory control, is more engaged at a later stadium of WS development.

It also needs to be noted that both the level of written speech and the level of executive functions are strongly connected to age, which can make it more difficult to discover their direct relations, especially in the scheme of cross-sectional studies applied in the present research. The investigation of relationships between EF and WS may be also hampered by their mutual influence as factors of development. It can be expected that the development of the higher mental function that written speech is will not only be based on EF, but will also contribute to their development (Bodrova et al., 2011). Such a bilateral relationship between EF and language, with which WS is strongly connected, has been described by Gordon-Pershey (2014).

The conducted research has several weak points that should be taken into consideration in planning further studies. First of all, it was conducted in the cross-sectional plan, which blocks the possibility to carry out cause and effect analyses, and to infer about developmental changes in the sphere of both written speech and executive functions. It is important for the reason that the development of literacy may not take the same form in all children because each component of the reading and writing process has a different dynamics of development (Krasowicz-Kupis, 2009; Paris, 2005). As a consequence, the statistical analysis based on variance or differences analysis is inadequate because it does not take into account the individual diversification of the results. Secondly, executive functions were measured in a very limited range and by one tool only. The obtained results cannot be, therefore, treated as a complex achievement of a child with respect to executive functioning. The lack of agreement among researchers about the interpretation of measurements conducted with the use of the CCS when no other method of meas-

uring executive functions has been applied, results also in limiting the possibility to refer the measurement of inhibitory control and cognitive flexibility exclusively to the behavioral level. This restriction is conditioned by the design of the data set used in the study, which had been collected in another research, what has already been signaled by the author earlier in the text. Of course, it would be interesting to study the relationship between EF and WS with the use of a greater number of measurement methods. The above limitation is the reason why the results obtained in the presented research can be interpreted from an exploratory perspective only. Thirdly, a widened control of the sample construction seems necessary. Apart from age, also SES should be controlled for, since it has been shown that it is an important factor of development of both executive functions (Sarsour, Sheridan, Jutte, Nuru-Jeter, Hinsh, & Boyce 2011; Sheridan, Sarsour, Jutte, D'Esposito, & Boyce 2012) and literacy (Brożek et al., 2013; Murawska, 2011). Also, the program of teaching reading and writing skills realized in kindergartens and at schools should be taken into account. The design of the sampling procedure limits significantly the possibility to generalize the results observed in the study. The fourth weak aspect of the study is at the same time its advantage: the high age diversification of the sample. On the one hand, it resulted in not completing all items in all tasks from the LAB by the youngest children, whereas for the older children some tasks from the LAB turned out to be too easy. In consequence, in the case of certain items from the LAB a lack of data was registered, whereas in the case of others, the discrimination power of the results turned out to be too low. It made it far more difficult to prepare the plan of statistical analyses. On the other hand, the examina-tion of such an age-diversified sample made it possible to interpret the results from a wider, developmental perspective, including both the preschool and the school period.

5. CONCLUSION

Treating learning to read and write as a process of formation of a new mental function appears to be promising. It allows a potential conceptualization of the relationship between reading and writing in the context of functioning of the entire mental system from the developmental perspective. Particularly important seems to be the possibility to analyze links between executive functions and early stages of written speech development, i.e., before starting formal training in reading and writing. Studying these links should, therefore, translate in the future into early detection of the risk of running into problems in learning to read and write and, at the same time, of problems in learning. It should also result in the future in the preparation of a systemic, thus covering all important factors, and evidence-based strategy of supporting the development of literacy. Designing the strategy of this kind is crucial especially, when we take into consideration the fact that in studies of the brain it has been already confirmed that there occurs a synchronic co-operation of cerebral systems responsible for reading, writing and executive functions.

AUTHOR'S NOTE

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