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LINGUISTIC STIMULATION IMPACT ON VERBAL WORKING MEMORY IN THE EARLY STAGES OF SCHOOL EDUCATION

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SUMMARY

Background: When studying cognitive flexibility in young children in bilingual programmes, a positive correlation has been noted between working memory efficiency and bilingualism. Research results point to the advantage in early vs. late or more proficient vs. less proficient bilinguals. The goal of this exploratory research was to investigate the importance of intensive language stimulation for the development of phonological short-term and working memory in children at the beginning of their school education.

Material/ Methods: The research was conducted in Northern Poland among 77 children attending two elementary schools: 42 children attended a Polish-language school (monolingual school group), and 35 children attended a school in which English was the language of instruction (bilingual school group). The children were tested twice: at the beginning and at the end of the first grade. Four tasks were administered: digit span, non-word repetition, phoneme discrimination and phoneme isolation.

Results: The analysis of longitudinal level changes showed a progressive development of the analyzed skills, irrespective of the school the children attended. However, different change dynamics in children attending the mono- or bilingual school have been observed. The progressive performance improvement in Zetotest, phoneme discrimination and phoneme isolation tasks was substantially higher in the bilingual school group when compared to the monolingual one. However, we reported no differences in the digit repetition skill between the groups. Moreover, the sex of a child appeared to be a strong determinant of verbal working memory development. In both stages girls performed better than boys.

Conclusions: Considerable advantage in phonological working memory processing has been reported after a year of bilingual education as compared to education within a monolingual context.

Key words: phonological working memory, mono- and bilingual children, phonological awareness

INTRODUCTION

The 21st century, can definitely be described as an era of "globalization", a term defined by Giddens as 'the intensification of worldwide social relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice versa' (Giddens, 1990, p. 64). This word carries an array of meanings among different people and disciplines. But the fact is that globalization is a historical process that has connected the world and influenced it, for better or worse, in nearly every aspect of life. The impact of English as a global language on educational policies and practices is undeniable. The development of the Internet, increased travelling opportunities, satellite television, more and more sophisticated means of communication, possibilities of working and studying abroad – all these factors strongly contributed to the fact that foreign language education had to be given a top priority. As an element of early education it is developing fast all over Europe, and not only Europe. According to the conclusions of the Barcelona European Council meeting of 15-16 March 2002 (cited in Council of the European Union, 2014) including a foreign language into the curriculum should be done at the earliest possible stage of education, preferably in kindergarten, given that children acquire a foreign language much faster and easier than adults. Compared to their European peers, prior to 2008, Polish children started their foreign language education relatively late. It is only since then that the Polish Ministry of National Education (2008) has introduced one obligatory foreign language into the first grade of elementary school and a second one in the first grade of Junior High School. Preferably, one of these languages is supposed to be English. In this way Polish pupils equaled their peers from Europe who start their second language education at the age of 6-9. In some countries, like for example in the German-speaking community of Belgium, even three year olds start to learn a second language and five-year-olds in Malta and Luxembourg (EACEA, 2012). The tendency to introduce a second language at the youngest possible age is spreading all over Europe and has not omitted Poland. From September 1st 2014 a foreign language is to be taught in kindergartens as a part of the curriculum at the discretion of head teachers. From 2015 this will be obligatory for 5-year-olds and for younger children from 2017 (Polish Ministry of National Education, 2012). It has been clearly stated by the European Commission (2011) that early foreign language education has a positive impact on pupils' general language skills, their attitudes towards other languages and culture as well as on their own self-confidence. The question remains as to whether young learners, already facing all the difficulties of elementary education, can cope with learning of an additional language.

When teaching a foreign language to such young learners as kindergarten children, it is not the measurable effect that is of principal importance but the right methodology as a result of which a proper foundation is constructed as well as motivation for further development As far as this period is concerned we should rather speak of the instilling of a certain language competence in children

which will constitute the basis for further second language acquisition (Komorowska, 2005)

Intensive exposure to two different languages may lead to bilingualism. This is generally understood as 'characteristic of individuals who possess or who use two linguistic systems' (Hakuta, Ferdman & Diaz, 1987, s. 284), however, multiple definitions of bilingualism take into account different factors of language acquisition such as context, age, etc. The age at which a child acquires the second language is one of the most important factors affecting the cognitive specificity of bilinguals and possible bilingualism outcomes. When two languages are acquired from birth (or before the age of 3, McLaughlin, 1978), then it is called simultaneous bilingualism. In contrast, when the second language is acquired after a child already possesses the basic concept of the first one (after 3 years of age), it can be defined as sequential bilingualism (Castilla, Restrepo & Perez-Leroux, 2009). Other important factors affecting possible advantages of bilingualism are: the levels of each language proficiency and the relative balance between the acquired languages (Bialystok, 2001; Cummins, 1979). Taking all this into account, bilinguals can be divided into balanced and partial (Peal & Lambert, 1962). It is generally accepted that the greater advantages emerge with greater (linguistic) competence (cf. Bialystok, 2001, p. 144) in both languages. Apart from the command of the second language, bilingualism has a significant impact on cognitive development. The research on 7-month-olds has already shown that simply hearing the two languages contributes to the emerging of cognitive advantages (Kovács & Mehler, 2009), and these advantages continue throughout one's lifespan (Bialystok, Craik & Ryan, 2006; Costa, Hernández & Sebastían-Gallés, 2008).

Numerous studies point to the fact that acquisition of a second language, especially during elementary school years or earlier, positively influences achievements in problem solving and conflict resolution (Bialystok & Majumder, 1998; Costa, Hernandez, Costa-Faidella & Sebastian-Galles, 2009; Diaz, 1983), reading and mathematics (Cumming-Potvin, Renshaw, & van Kraayenoord, 2003; Stewart, 2005) as well as understanding about the vocabulary and structure of one's own language (Cumming-Potvin, Renshaw, & van Kraayenoord, 2003). Additionally participation in two different linguistic environments allows a dual language child to become more attuned to various subtleties of communicative interactions (Berguno & Bowler, 2004), it widens its understanding of geographical and cultural perspectives and enhances the learning of other subjects such as social studies, science, art, and music (Stewart, 2005).

When studying cognitive flexibility in young children in bilingual programmes, a positive correlation has been noted between bilingualism and non-verbal measures of their cognitive ability including memory.

The relation between memory and language has been explored by neuropsychologists since the middle of the 20th century, especially in respect to aphasia (Pąchalska, Kaczmarek, & Kropotov, 2014). In the classical model, the connection between processes of memory and language has been described in accordance with the concept of working memory (Baddeley & Hitch, 1974). In this

model the role of a language in processing memory material was emphasized by distinguishing the "phonological loop" (short-term memory), which constitutes a system for the storing and rehearsal of verbal information. Phonological working memory controls the maintenance of auditory information in the phonological loop and involves the active manipulation of information while storing other information at the same time (Baddeley, 2003; Baddeley, Gathercole, & Papagno, 1998; Baddeley & Logie, 1999; Swanson, Saez & Gerber, 2006). The linguistic aspect of working memory has been the focus of numerous neuropsychological research, involving both patients and healthy individuals (Pąchalska, 2008; Francuz, Borkowska, Soluch & Wolak, 2013). In reference to long term memory, also, the role of a language has been incorporated in a general theory of memory. Tulving (2000), on the basis of the format of the information stored in memory, distinguished "semantic memory," which is an organized store of knowledge about the meaning of words and concepts, or remembered facts. Current research has of course gone far beyond Baddeley's concept of working memory, or Tulving's semantic memory; however, the connection between language and memory has not only not been disproven, but in fact emphasized.

In order to function effectively, bilingual persons must keep the languages functionally distinct. Studies have shown that the constant use of two languages generates changes in the configuration of the executive control network. As a result, more efficient performance in executive control tasks has been observed, also nonverbal ones, and is observed at all stages of the human lifespan. These advantages seem to contribute to the increase in cognitive reserve, enabling bilinguals to cope better with dementia, particularly of Alzheimer's type or even postpone the appearance of its symptoms at the very onset of the disease (Bialystok, 2011).

Additionally, simultaneous and sequential bilinguals more than monolinguals rely on their short-term memory during the auditory recognition of words (Kaushanskaya, Blumenfeld & Marian, 2011). Studies indicate a positive relationship between working memory efficiency and bilingualism, however they point to the advantage in early vs. late or more proficient vs. less proficient bilinguals (Ardila et al., 2000; Bajo, Padilla & Padilla, 2000).

The goal of this exploratory research was to investigate the importance of intensive language stimulation for the development of phonological short-term and working memory in children beginning intensive second language acquisition at the age of 6 or 7 (sequential bilingualism). So we have constructed it in a way that would enable us to compare the development of these skills in children at the beginning of their school education: in the monolingual school (control group) or the school with a foreign language as the language of instruction (criterion group). Hence children in the criterion group experience strong stimulation from both - the first language which they use at home on a daily basis as well as they learn to read and write in it, and the second language which is taught to them intensively at school so that they would be able to fully participate in classes.

Phonological short-term and working memory is an important determinant of the reading acquisition process and the process of reading itself. Phonological loop (proper auditory perception of particular sounds and the storage of their sequence in memory) is indispensable for every phonological awareness task regardless of its complexity (Schuele & Boudreau, 2008). Similarly executive processing which distributes attentional resources to the phonological loop is required to perform phonological awareness tasks (cf. Park, Rotter, Lombardino, Wiseheart & Sherman, 2014). The proper functioning of these skills determines the full understanding of the utterance (oral or written one). Phonological memory measurement is extremely important from the point of view of phonological awareness tests offered to children, during which they perform phonological operations in their minds without the use of sight (children cannot see the words dictated to them by the researcher).

In our research we have taken into account the specific cultural and linguistic specificity of Poland as being generally a mono-cultural country. According to the Polish Governmental Office for Foreigners 2013 data, 121 thousand foreigners living in Poland constitute 0.3% of the whole population (Polish Governmental Office for Foreigners, 2013), whereas in the Polish census of 2011, 1.5% of the surveyed declared a national or ethnic identity exclusively different than Polish, and 2.26% declared that they identify with both, Polish and another ethnic and cultural minority (mainly Silesian, Kashubian, German, Ukrainian and Belarusian) (Central Statistical Office of Poland, 2013). Bilingual persons are in the minority, however, in the majority of big cities there are schools offering education in a language of instruction different than Polish. They put emphasis on broad language development, most often in a language immersion system that leads to balanced bilingualism.

MATERIAL AND METHODS

The research was conducted in Northern Poland in the years 2010-2012 among 77 children attending two elementary schools: 42 children attended a Polish-language school (monolingual school group), and 35 children attended a school in which English was the language of instruction (bilingual school group).

This was a longitudinal study. The children were tested twice: at the beginning of the first grade (in September) and the second time at the end of the first grade (in June). The whole group during the initial stage of testing had an average age of 7.1 years. The first project stage took place right after the beginning of the school year (first grade), therefore the impact of the school curriculum and the language of instruction was very limited at that moment.

All the participants had Polish nationality, and Polish language was their mother tongue, and the only language spoken at home. The studied children did not have any experience of previous intensive foreign language acquisition, but all of them had attended extracurricular language classes at kindergarten age, with this being mostly play-based learning. None of the children had a fluent

command of English when they began their education at the school where this was the language of instruction. All of the participants met the following criteria: normal or above intelligence, normal or corrected to normal visual and auditory acuity, no gross sensory deficit, no gross behavioral problems, no history of neurological disease, no diagnosis of the risk of specific learning difficulties (SLD).

The chosen schools did not differ from each other in terms of the Polish literacy training system (the same textbook and teaching methodology were used), the social and economic status of parents – high SES (both schools were small privately-run institutions offering an education from grade 0 to grade 6 at elementary level). However, they differed in terms of the predominant language of instruction, which constituted the basis for the identification of the two studied groups.

The bilingual school group attended an institution where from Grade 1, the majority of classes (apart from Polish language and religion) are conducted in English. The pupils receive simultaneous literacy training in Polish and English, and are expected to become bilingual at the end of elementary education (i.e. after six years of education). The monolingual school group obtained the majority of classes (apart from the English as a foreign language classes – 3 hours weekly in Grade 1) in Polish language. Therefore, children attending this school received a Polish literacy training, while English is implemented as a foreign language, beginning at Grade 1, albeit to a very limited degree.

The study was carried out individually with each child. Children's IQ was assessed with the Raven's Progressive Matrices Test (Polish adaptation: Jaworowska & Szustrowa, 1991). Analysis of the Raven's scale scores revealed that the studied children showed a higher level of intellectual functioning than the age-specific norm.

In order to analyze the phonological working memory functioning, we used four tasks:

- repetition – measuring the phonological working memory (phonological loop component of the working memory according to Baddeley, 2003):
  - digit span – subtest from WISC-R – adapted to Polish norms (Matczak, Piotrowska & Ciarkowska, 2008)
  - non-word repetition - Zetotest (Krasowicz, 1995)
- comparison – measuring the phonological working memory (phonological loop) together with the ability to discriminate phonemes (fundamental to the task of analysing paronymous non-words):
  - phoneme discrimination - comparison of the paronymous non-words (Bogdanowicz et al., 2010).
- verbal working memory (requiring besides phonological loop also a central executive component to support processing) and phonological awareness task:
  - phoneme isolation - structural analysis of the paronymous non-words (Bogdanowicz et al., 2010).

Digit Span is a component of both WMS-III Battery (Wechsler, 1998) and Wechsler Intelligence Scales, in two versions: for children (e.g. WISC-R officially used in Poland in the diagnosis process) and for adults. The researcher reads the series of digits and asks for them to be repeated in the same sequence. Next

he/she reads a new series of digits and asks for them to be repeated but in the reverse order. In both versions the studied person is presented with longer and longer sequences of digits. In WISC-R the results obtained in outright and backwards condition are summed up and the total result constitutes the basis for the description of the converted results and are used in the process of intelligence assessment and profile analyses (Matczak, Piotrowska & Ciarkowska, 2008). In neuropsychological assessment, children's test scores are regarded as indicators of auditory rote memory, direct retrieval, sequential processing and information coding for its later processing (Krasowicz-Kupis & Wiejak, 2006). It is worth noting that performing this subtest engages not only memory and attention processes but also linguistic ones involved in voiceless repetition of registered material (Pąchalska, 2008). Digit repetition performance is correlated with age and, according to the developmental approach, is regarded as an indicator of direct auditory memory capacity (Ostrosky-Solís & Lozano, 2006).

Zetotest examines phonological working memory. It consists of 28 non-words of different length. The researcher reads aloud one non-word after another and asks the child to repeat it. The use of non-words reduces the impact of meaning on memorizing the words. The presented non-words are of different length (from two syllable to five syllable ones), they all consist of open syllables and contain sounds which are characteristic for Polish as a language. The maximum score is 28 points, 1 point for every correct repetition (Krasowicz, 1995).

Two other tasks (the comparison and the structural analysis) assess phonological awareness together with phonological working memory. They consist of 25 pairs of paronymous non-words that differ from each other in one sound and are adjusted for the specificity of the Polish language (e.g. ***ż**rof* – ***sz**rof, e**k**ra* – *e**g**ra, **b**ni-**p**ni).* The comparison task is aimed at diagnosing the ability to discriminate phonemes. The participants are asked to decide if two given non-word paronyms sound the same or different. The maximum score in the task is 25. The structural analysis task is much more attention and executive control (incl. phonological working memory) demanding. Apart from a proper perception of the subtle differences between phonemes, it also requires a well developed phonological working memory (the ability to retain verbal information while comparing sounds of two non-words, isolate the differing one and sounding it out). During this task if a child previously decided that two non-word paronyms in a given pair differed from each other, the researcher asked about the exact nature of the difference between these non-words. Therefore, the participant should identify the sound differing non-words within the pair. The maximum score in this task was 19 (Bogdanowicz et al., 2010).

RESULTS

Statistical analysis was conducted with Statistica 10 software (*MANOVA*, post-*hoc* analysis (*Tukey Test* for unequal sample sizes and *Multiple Regression analysis*).

The results of the tests obtained during the first stage of the study (in September, at the beginning of the first grade of elementary school) indicated that at the beginning of the primary school the children participating in the project obtained high results in all tasks regardless of the school they attended. The results of the group comparison are presented in Table 1.

Paronymous words comparison appeared to be a simple task for the children, the average score was 23 points out of 25, apparently close to the ceiling effect. The structural analysis task, differentiating two given non-words turned out to be substantially more difficult for children, the average performance ranged from 11 to 19 points.

The results do not reveal any statistically significant differences between schools in the area of all the skills studied . The analysis of longitudinal level changes showed progressive development of the analyzed skills, irrespective of the school the children attended.

The results have been presented in Table 2

The improvement in the range of working memory is not surprising but rather expected regarding developmental regularity. The age factor is one of the most important determinants of memory functioning (Hester, Kinsella & Ong, 2004). However, different dynamics of changes in children attending the mono- or bilingual school were observed.

There were no progressive improvement differences in the digit repetition skill between the groups during a year. Children from both schools presented a comparable short-term memory of digit span, whereas in other tasks some differences in progressive improvement were observed. The analyses of the Zetotest results, assessing phonological short-term-memory, revealed that in both schools children obtained significantly higher results in the second study than at the beginning of the school year (bilingual school group: $t = -20.95$, $p < .01$, monolingual

Table 1. Interschool comparison of the results obtained in the first study

Tasks – stage I	Bilingual school group		Monolingual school group		Difference	
	M	*SD*	*M*	*SD*	*t*	*p*
digit span (converted)	11.34	2.33	11.55	1.97	0.42	.677
nonword repetition	22.17	1.72	21.10	2.83	1.97	.053
phoneme discrimination	23.17	2.05	22.79	1.93	0.85	.399
phoneme isolation	11.29	1.99	11.02	2.52	0.50	.620

Table 2. The analyzed skills comparison at the beginning (the first study) and at the end (the second study) of the first grade of elementary school, in both schools together

Task	Stage I		Stage II		Difference	
	M	*SD*	*M*	*SD*	*t*	*p*
digit span (converted)	11.45	2.12	11.38	1.94	0.79	.434
nonword repetition	21.58	2.44	25.26	2.94	20.79	<.001
phoneme discrimination	22.96	1.98	23.95	1.57	4.90	<.001
phoneme isolation	11.14	2.29	13.40	2.36	11.38	<.001

Table 3. Test results comparison between bilingual school group and monolingual school group in the second stage of the study

Tasks – stage II	Bilingual school group		Monolingual school group		Difference	
	M	*SD*	*M*	*SD*	*t*	*p*
digit span (converted)	11.40	2.12	11.36	1.81	0.10	.924
nonword repetition	26.86	1.33	23.93	3.26	4.98	<.001
phoneme discrimination	24.40	0.91	23.57	1.88	2.38	.020
phoneme isolation	14.46	2.12	12.52	2.21	3.89	<.001

school group: $t = -15.46$, $p < .01$), but the progressive improvement was much higher in the English-language school group (Table 3).

A similar situation occurred in the phoneme discrimination task (bilingual school group: $t = -3.87$, $p < .01$, monolingual school group: $t = -3.05$, $p < .01$), and in the paronymous non-words analysis task (phoneme isolation), bilingual school group: $t = -10.12$, $p < .01$, monolingual school group: $t = -8.00$, $p < .01$), in both schools the results were significantly higher at the end of the first grade than at the beginning of the school year. However, the progressive performance improvement in these three tasks was substantially higher in the English-language school group when compared to the school where Polish language prevailed. The results of the interschool differences observed in the second study have been presented in Table 3.

Moreover, the sex of a child appeared to be a strong determinant of verbal working memory development. MANOVA (2: the sex x 2: type of school) has revealed differences between the first ($F = 9.22$, $p = .003$) and the second ($F = 8.67$, $p = .004$) digit span measurement, considering the sex instead of the type of the school. Post-hoc analysis (Fisher's NIR test) showed that in both, the first and the second stage, the girls performed better than the boys (respectively: $p = .003$, $p = .005$). Interaction between the school and the sex of a child has appeared in the non-word repetition test in both, the first and the second measurement ($F = 15.90$, $p < .001$). The girls from the bilingual school group obtained the highest scores in the non-word repetition test during the first stage ($M = 22.38$, $SD = 1.66$), whereas the boys from the monolingual school group obtained the lowest results ($M = 20.18$, $SD = 3.46$). In the second stage the situation was similar, the girls from the bilingual school group also preformed best ($M = 27.31$, $SD = 1.18$) and the boys from the monolingual school group had the lowest rate ($M = 23.05$, $SD = 4.05$). No significant differences have been observed in the first stage of phoneme discrimination, but in the second one ANOVA reveals an interaction effect ($F = 8.03$, $p = .001$). Here the highest score belongs to the girls from the monolingual school group ($M = 24.60$, $SD = 0.88$), and the lowest one to the boys from the same school ($M = 22.64$, $SD = 2.07$). As far as phoneme isolation is concerned, the main effect concerns the sex in the first stage ($F = 4.61$, $p = .035$), the girls scored somehow better than boys ($p = .041$) whereas during the second stage an interaction effect has emerged between the sex and the school ($F = 10.53$, $p < .001$). Here the highest score belongs to the boys from

the bilingual school group (M = 14.55, SD = 2.34), and the lowest one to the boys from the monolingual school group (M = 11.50, SD = 2.20).

DISCUSSION

The results of our study revealed that the analyzed groups differed in the dynamics of acquiring a phonological working memory. Polish children attending the school with English as the language of instruction (aimed at the bilingual development of the pupils), received higher results in one out of two tests measuring phonological short-term-memory – repeating non-words but not numbers – and higher results in phoneme discrimination (comparing two paronymous non-words) and phonological processing (phoneme isolation) compared to the results of Polish children attending the monolingual school (with Polish as the language of instruction). Taking into account that both schools had a comparable curriculum (excluding languages), number of pupils in class, number of lessons daily, SES of families, we may conjecture that the differences result from the intensity of linguistic stimulation or the specificity of the language of instruction. Similar results were obtained in a study of Polish children in grades 0-3 (Pawlicka, 2012). Also Sakuma and Saito's research (2012) has confirmed the progressive improvement of verbal working memory and increased sensitivity to particular phonological forms among students exposed to an intensive programme of foreign language learning.

Advantages in phonological short-term-memory (phonological loop component of working memory) have been reported for bilingual children who acquired vocabulary proficiency in both languages at a later time and shift from dominant to additive bilinguals (Kudo & Swanson, 2014). Van Kleeck, Gilla and Hoffman (2006) obtained similar results in a group of preschoolers with language impairment – an intervention aimed at enhancing phonological awareness skills has also improved their working memory.

It is worth noting that after a year of different kinds of language stimulation, there were no differences between children from mono- and bilingual schools only in the field of verbal short-term-memory assessed with digit span test. The results of meta-analysis by Engel de Abreu & Gathercole (2012) also revealed the significant relationship between non-word repetition and vocabulary in a third language at the initial stage of its acquisition, however no such relationship has been found in the case of digit span.

This kind of subtest is strongly attention oriented (Hale, Hoeppner & Fiorello, 2002) and age dependent (Myerson, Emery, White & Hale, 2003), but is also connected with the stage of education and the level of intellectual functioning (Borkowska & Ozimek, 2014). The relation between digit repetition ability and language functioning manifests itself mostly in reference to children with neurodevelopmental disorders, especially with ADHD (Lipowska, 2011), developmental dyslexia (Helland & Asbjørnsen, 2004) and specific language impairment (Ziethe, Eysholdt & Doellinger, 2013), but also with borderline intellectual func-

tioning (Jankowska, Bogdanowicz & Takagi, 2014). As far as clinical groups are concerned, significantly stronger diagnostic power is assigned to digit repetition in reversed order condition, however, the majority of research points to the relation between poor performance in reverse order tasks in people with left hemisphere impairment (Marchand, Lefebvre & Connolly, 2006).

When compared to digit material operations, memory operations based on linguistic material containing non-words require much more sensitivity to the critical features of particular language. Digit repetition is relatively easier than repeating non-words because, on a large scale, it refers to the semantic rather than only the phonological competence of a person. The simultaneous and intensive teaching of two languages to small children increases their sensitivity to the subtle differences between words and forces to reproduce them with more attention to accuracy.

CONCLUSIONS

Our overall results from the study that analyzed the role of linguistic stimulation intensity (school instruction in L1 or in L2 which is a foreign language not known earlier) in working phonological memory indicate that:

- considerable advantage in phonological working memory processing has been reported after a year of bilingual education compared to education in a monolingual context,
- intensive language stimulation increases mainly the phonological aspect of working memory together with phonological awareness – important determinants of the reading acquisition process and the process of reading itself,
- the results indicate the neurolinguistic aspects of second language acquisition and emphasize the importance and reasonableness of introducing a foreign language to children at the earliest stages of education.

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