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How children with developmental language disorders solve nonverbal tasks

While solving tasks that test their intelligence, children suffering from developmental language disorders (DLD) usually receive lower scores than their typically developing (TD) peers. The present study aimed to assess how children with DLD solve typical nonverbal tasks. Sixty-five children (ages 6-9 years), monolingual users of the Polish language, participated in this study (34 with DLD, 31 TD). The Test of Language Development (TLD) was used to assess language development. Three tasks from the ABC II Kaufmann were used: triangles, story completion, and conceptual thinking. Children with DLD scored significantly lower than TD children in conceptual thinking and story completion. Scores on the triangles test did not correlate significantly with scores on the linguistic tests, whereas conceptual thinking and story completion were highly intercorrelated. While solving the task that required choosing an object that does not match other objects, children with DLD frequently selected different answers than TD children.

Key words: developmental language disorders, nonverbal tasks, categorization

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According to the International Classification of Diseases, 11th edition (ICD-11), developmental language disorders (DLDs) are diagnosed when "[an] individual's ability to understand, produce or use language is markedly below what would be expected given the individual's age and level of intellectual functioning" (WHO, 2019). DLDs are defined in a similar way in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5), wherein it is also noted that "the difficulties are not attributable to hearing or other sensory impairment, motor dysfunction, or another medical or neurological condition and are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay" (American Psychiatric Association, 2013, p.42). Thus, in order to diagnose DLDs, it is necessary to assess a patient's general intellectual abilities.

Assessment of a patient's intellect must necessarily involve nonverbal tasks, which ensures that linguistic skills do not corrupt the results. Thus, nonverbal tasks should use as little language as possible, and answers should not be given with the use of language. Some non-verbal tasks also have instructions presented in a nonverbal manner, for example, by gestures or demonstration (DeThorne & Schaefer, 2004). This form of testing should allow persons suffering from language disorders to present their true intellectual abilities. However, numerous studies show that children with language disorders receive lower scores in nonverbal tests than their typically-developing (TD) peers. For example, Gallinat and Spaulding (2014) performed a meta-analysis of 131 studies comparing the scores of standardized nonverbal IQ tests taken by TD children and children with specific language impairment (SLI) – a term that was formerly used for DLD. The term "DLD" was adopted following a discussion that occurred in 2015-2016 (cf. Bishop et al., 2017, 2016) Results of the meta-analysis demonstrated that children with SLI scored 0.69 SD lower than their TD peers in nonverbal IQ tests. Similar results were obtained in a more recent study by Liao et al. (2015), who demonstrated that children with language disorders received lower scores than TD children on nonverbal tasks (i.e., matrix reasoning and picture completion) in the Wechsler Preschool and Primary Scale of Intelligence – Revised–Chinese version.

Thus, the questionarises: Do these results reflect actual lower general abilities of DLD children, or are the lower scores related to the methods used to evaluate IQ? It has been noted that children with language disorders may experience difficulties in understanding verbal instructions (Gallinat & Spaulding, 2014). Indeed, internal speech and the ability to create narratives might play a significant role in the process of solving many tasks, given that these functions are based on language (Lidstone et al., 2012). Thus, even though the testing procedure does not require the use of language, language might be employed in the process of solving tasks and, as a result, might influence the answers and scores.

However, this interpretation seems to be incomplete in the context of other studies. In a longitudinal study (Botting, 2005), 82 children with language disorders were tested at four time points: at the ages of 7, 8, 11, and 14 years.

The difference in average IQ between the first two time points was minimal - an increase of 3 IQ points. However, at later timepoints, there was a decrease in IQ scores. In particular, the average IQ at age 11 was 86, and at age 14, the average IQ declined to 83. Altogether, there was an average decrease in IQ of 22 points within 7 years. Detailed analyses demonstrated that in roughly 1 in 4 children (i.e., 20 out of 82), the decrease was slight and the obtained results were within the average range. However, in more than 60% of the children (i.e., 52 out of 82), the decrease was significant and for a major part of this sub-group, the scores in the last two time points were significantly lower than the average. The remaining 12% of children (i.e., 12 out of 82) achieved scores that were below average starting at the first time point. The children in the first subgroup with slightly decreased scores suffered from mild language disorders, while those in the two remaining subgroups suffered more severe impairment. In a similar study, Conti-Ramsden et al. (2012) conducted a 10-year prospective study, testing children at age 7 and again at age 17. The results were not as conclusive. A decrease in IQ measured with nonverbal techniques was observed in 32% of the children. For the majority of the remaining children, the results were consistent and did significantly differ with age. An increase in IQ was observed in a small number of children (7%).

The reasons for lower scores obtained in an IQ test and the observed age-related decrease in children suffering from language disorders still remain unclear. These questions may be related to the fact that language disorders are comorbid with other types of cognitive impairment, particularly deficits in short-term memory and executive functions (Henry et al., 2012; Kuusisto et al., 2017; Montogmery et al., 2010). Conversely, linguistic deficits may influence the way in which cognitive processes operate.

Aims of the Study

The current study aimed to analyze the performance of nonverbal tasks by children with DLD and a control group with typical development. Three research questions were asked:

1. Do children with DLD differ from children with TD in terms of the results obtained on nonverbal tasks? If so:
2. Is linguistic proficiency linked to nonverbal tests?
3. Are there qualitative differences in solving the tasks?

To answer the third question, a detailed qualitative analysis of the answers given during categorization tasks was conducted. This approach made it possible to discover the processes that children suffering from language disorders use while they categorize and to define the differences between them and the processes used by TD children.

Method

Participants

This study included a total of sixty-five children, aged 6-9 years. All children were brought up in a monolingual environment: their native language was Polish. Children were divided into two groups:

1. DLD (n = 34, average age: 88 months). The DLD group consisted of 25 boys and 9 girls, which is consistent with the higher rate of DLD among males than females (Hulme & Snowling, 2009). Criteria for inclusion were: results in Test of Language Development (TLD) ≤ 3 stanine; results in at least wo TLD subscales ≤ 2 stanine; delayed speech development in the first three years of life (information from parents); Raven's Colored Progressive Matrices: results ≥ 20 percentile.

2. TD children (n = 31, average age: 89 months), who were matched on age and socioeconomic status (SES) to those in the DLD group. The TD group consisted of 19 boys and 12 girls. Criteria for inclusion: results in TLD (general results and results in all subscales) ≥ 4 stanine; proper speech development; Raven's Colored Progressive Matrices: results ≥ 20 percentile.

Criteria for exclusion were the same in both groups: impairment of hearing and vision (except small defects corrected with glasses), neurological illnesses and other health problems that could influence cognitive functioning, bi- or multilingualism.

Sex distribution did not differ significantly between the two groups (χ^2 = 1.11, p = 0.29). All children lived in a large city, were from middle or upper-middle class families (at least one parent had a complete university education and was employed adequately to their education). All children attended primary schools that followed the standard curriculum. The latter as critical, as some children with DLD are members of so-called "integrated classrooms" in which children with various disabilities learn together with nondisabled students.

The groups did not differ in the results on the Raven's Progressive Matrices text (DLD mean: 58.26, TD mean: 60.48, $t[63] = 0.52$, $p = .60$).

Measures

The Test of Language Development (TLD, Polish name: Test Rozwoju Językowego, TRJ) was used to assess linguistic development. The TLD was originally published in Polish in 2015 (Smoczyńska et al, 2015), and is divided into five tasks: word comprehension, word production, sentence repetition, sentence comprehension, and word inflection production. Results are summarized as cumulative scores corresponding to four subscales: lexicon, grammar, comprehension, and production. The TLD has been standardized for ages 4.0 to 8.11, and scores are presented on a stanine scale. Total scores are also given on a centile scale. Scores at or below the third stanine are thought to indicate deficits in language development.

Three tasks from the ABC II Kaufman set (Kaufman & Kaufman, 2004) were employed to test nonverbal functions:

1. Triangles: The child arranges a figure using yellow and blue triangles according to a pattern that is shown. Completing the task in a short time is rewarded with extra points.
2. Story completion: A visual story is shown and some images are missing. The child is instructed to choose the images that match the story from a set of various pictures and place them in correct slots. Completing the task in a short time is rewarded with extra points.
3. Conceptual thinking: A board with four or five objects drawn on it is shown to the child. The child is instructed to indicate which object is the odd one out.

These tasks were selected because they represent tasks that are commonly used in nonverbal intelligence tests. Moreover, the fact that the ABC II Kaufman does not have a Polish standardization was significant, as it means that the test is not used in diagnostic procedures. Therefore, it could be assumed that the children had not encountered the test material before. Scores were compared against norms defined for particular age groups published in the American handbook (for triangles and story completion scores), and raw scores were used for conceptual thinking, given that there is no standardization for older children.

Children were examined during one meeting lasting about 80 minutes. All examinations were conducted by the same psychologist.

STATISTICA 12 software was used for statistical analyses. The distribution of the results was normal, so Student's t test for independent groups, χ^2 test, and Pearson's r test (with Bonferroni correction for multiple comparisons) were used.

Results

There were significant differences in the TLD results between the DLD and TD groups. Children in the DLD group scored lower on all TLD subscales, whereas the children in the TD group showed scores within the average level (see Table 1). These data indicate that the groups were selected and assembled adequately.

For nonverbal tasks, there were significant group differences in scores on conceptual thinking and in story completion, but no group differences in scores on triangles (see Table 1). Potential correlations between nonverbal tasks and the tasks and subscales of the TLD were also tested. Very high correlations were observed in all linguistic tasks for conceptual thinking and story completion, whereas minor, not statistically significant correlations were found for Triangles (see Table 2).

Average overall scores on conceptual thinking differed considerably between the groups. During the tests and initial analysis of the collected data, differences in the distribution of answers provided by the children for particular test items were

Table 1. Scores on the Test of Language Development and Nonverbal IQ Testing

		DLD (n = 34) M (SD)	TD (n = 31) M (SD)	t(63)	Effect size*	p
TLD scales	TLD – full scale	2.27 (1.26)	6.51 (1.90)	10,62	>1	< .0001
	Lexicon	2.24 (1.50)	6.39 (1.31)	11.23	>1	< .0001
	Grammar	2.45 (1.42)	6.19 (2.10)	8.39	>1	< .0001
	Comprehension	2.61 (1.56)	6.16 (1.39)	9.59	>1	< .0001
	Production	2.33 (1.27)	6.48 (2.06)	9.76	>1	< .0001
Nonverbal tasks (ABC II Kaufman)	Triangles	12.79 (2.87)	13.42 (2.91)	.87	.14	.39
	Story completion	9.09 (2.14)	11.87 (2.46)	4.84	.98	< .0001
	Conceptual thinking	18.53 (1.83)	21.17 (2.96)	4.38	.98	< .0001

Note. TLD = Test of Language Development; DLD = Developmental Language Disorders; TD = Typically developing children.
*Effect size: Cohen's d: 0.20 = small; 0.50 = medium; .80 ≥ large (Cohen, 1988).

Table 2. Scale Correlation for Test of Language Development and Nonverbal Tasks

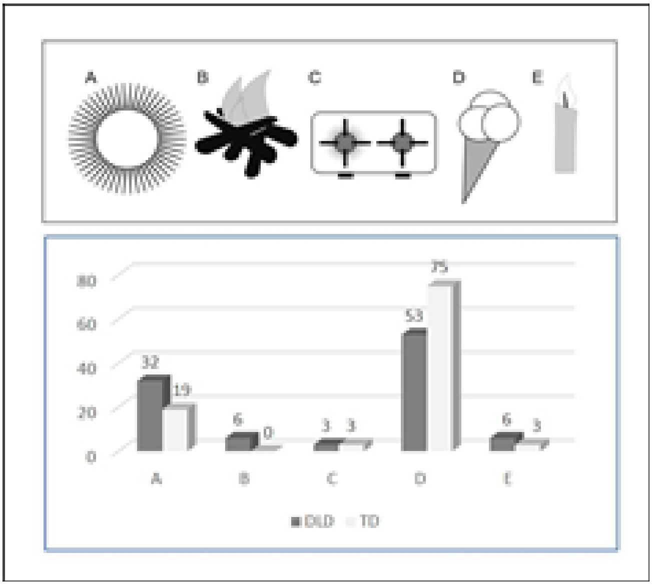
		Triangles	Story completion	Conceptual thinking
TLD scales	TLD – full scale	$r(63) = .18, p = .16$	$r(63) = .56, p < .000$	$r(63) = .53, p < .000$
	Lexicon	$r(63) = .13, p = .30$	$r(63) = .54, p < .000$	$r(63) = .50, p < .000$
	Grammar	$r(63) = .21, p = .09$	$r(63) = .49, p < .000$	$r(63) = .50, p < .000$
	Comprehension	$r(63) = .20, p = .13$	$r(63) = .58, p < .000$	$r(63) = .52, p < .000$
	Production	$r(63) = .18, p = .17$	$r(63) = .50, p < .000$	$r(63) = .51, p < .000$
TLD tasks	Word comprehension	$r(63) = .15, p = .26$	$r(63) = .52, p < .000$	$r(63) = .47, p < .000$
	Word production	$r(63) = .10, p = .44$	$r(63) = .52, p < .000$	$r(63) = .53, p < .000$
	Sentence repetition	$r(63) = .10, p = .45$	$r(63) = .35, p < .000$	$r(63) = .37, p = .003$
	Sentence comprehension	$r(63) = .24, p = .06$	$r(63) = .52, p < .000$	$r(63) = .54, p < .000$
	Word inflection production	$r(63) = .20, p = .12$	$r(63) = .49, p <. 000$	$r(63) = .50, p < .000$

Note. The significance level with Bonferroni correction for multiple comparisons was .002.

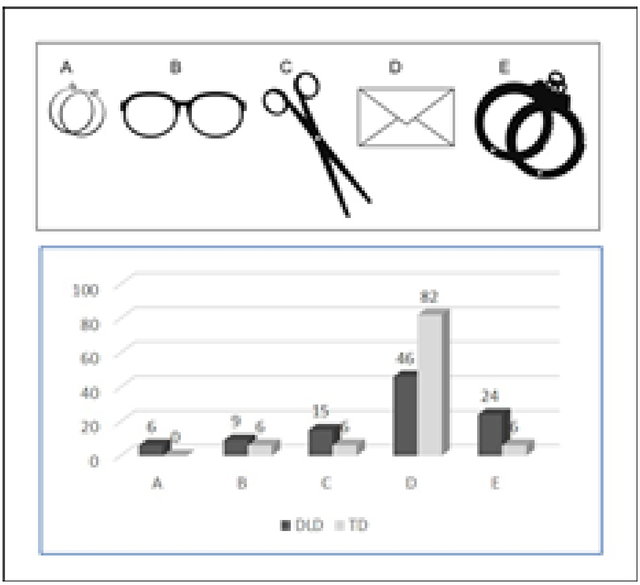
noted. In particular, for some of the tasks, a large number of children with DLD chose incorrect answers (compared against the key), but they were not random. The incorrect answers were concentrated around one of the distractor items. For these items, a difference between the distribution of answers provided by children with DLD and TD was observed. Typical examples are illustrated in Figure 1.

Some children were vocalizing their thinking process as they were solving the tasks, or spontaneously commenting on their answers. However, the testing procedure did not ask children to explain why they had chosen their answer. Thus, in the task presented in Figures 2 and 4, for the handcuffs, the following comments occurred: "tego nie masz w domu," "to nie do używania, tylko policjant może" ("you don't have this at home," "this is not for using, only a

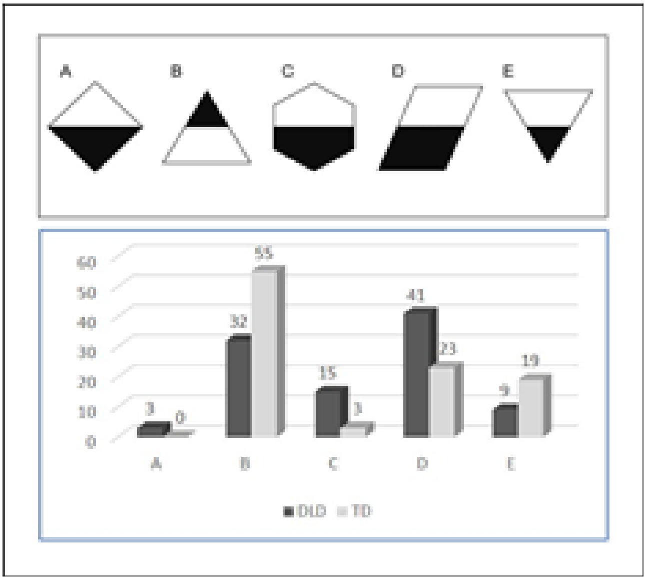
Figure 1. *Distribution of responses in the DLD and TD groups in Conceptual Thinking.*



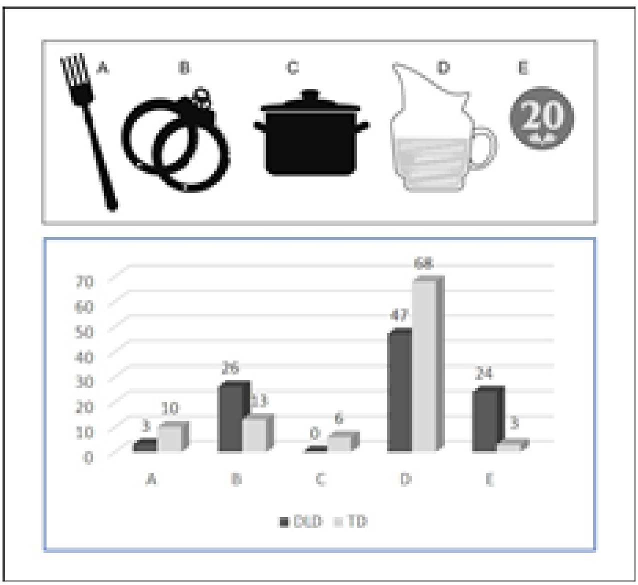
Panel A: $\chi^2 = 5.08$, $p = .28$



Panel B: $\chi^2 = 10.04$, $p = .04$



Panel C: $\chi^2 = 8.85$, $p = .06$



Panel D: $\chi^2 = 12.52$, $p = .01$

Note. On the Y axis, the percentage of choices. The drawings do not present real items from the test, but only symbolically reflect their character.

policeman can," respectively) and for a coin: "to nie jest polskie," "takiego w Polsce nie ma, a te są" ("this is not Polish," "this can't be found in Poland, but these can," respectively). In a chart presented in Figure 1, choosing the sun as the odd picture was justified by a child in the following way: "słońce jest, a tamto są zrobione" ("the sun is, but that are made" – original grammar).

Discussion

The results showed that children with DLD obtained significantly lower results on some nonverbal tasks. These were the conceptual thinking and story completion tasks, which correlated strongly with all language tests. This is a significant result, as this type of task appears in many tools that are used to measure intelligence. For example, a classification based on indicating an odd element is the foundation of the Columbia Mental Maturity Scale (Burgemeister et al., 1972). Other tasks based on defining distinct categories and their matching elements appear in the Wechsler Intelligence Scale for Children (Wechsler, 2014), the Wechsler Preschool and Primary Scale of Intelligence (Wechsler, 1989), and the Intelligence and Development Scales (IDS, Grob et al., 2009). Constructing stories out of pictures was included as a task in one of the earlier editions of Wechsler's test. Tasks based on the reconstruction of a presented pattern using geometrical shapes are also used in Wechsler's scales, the Stanford-Binet scales (Roid, 2003), the IDS, and many other tests. These are nonverbal tasks that do not require verbal answers to solve them. However, in the three types of tasks that were analysed in the current study, the only one that did not correlate with the results of linguistic tests was the one based on reconstructing patterns (i.e., Triangles). The triangles task is based on, above all, spatial visualization ability and very few linguistic processes are needed.

Children's language abilities correlated strongly with scores obtained on tasks that are based on constructing visual stories and classifying objects presented in pictures. These results might be explained by the importance of linguistic operations in the process of solving these tasks.

It is helpful to create a narrative, or a story based on the pictures, while one tries to fill the missing pictures. When a child experiences difficulties in this ability, which is typical in the case of DLD (Blom & Boerma, 2016; Wetherell et al., 2007), it might be challenging for the child to recognize events and illustrate them by arranging or filling in the pictures. At times, it is difficult for a child with DLD to maintain the continuity of causes and effects, and the story disintegrates and changes into a few separate plots.

The ability to create narratives and to maintain a logical continuity of events is associated with both vocabulary (Heilman et al., 2010) and the ability to create dependent clauses (Bishop & Donlan, 2005). These observations are confirmed by the high correlations between the scale' results for vocabulary and grammar in the TLD and story completion obtained in the current study. These correlations also indicate that, even when a child is not expected to tell the story shown in the pictures, linguistic functions and internal narratives are important in the process of constructing the story.

Likewise, categorization processes, even when they are performed with visual materials, are largely based on linguistic experience, given that they involve naming and describing objects and events (Bloom & Keil, 2001; Győri, 2009). Twenty-month-old infants can categorize using the names of objects. This issue is also studied in a traditional way in an intercultural context, wherein scores obtained by speakers of various languages are compared. Results of these intercultural studies show differences in the processes of forming categories that depend on the existence and limits related to names in a given language (Lupyan et al., 2018; White et al., 2016).

Experimental studies involving typically-functioning people also show that limiting vocalizations may influence the efficiency of categorization (Lupyan, 2009, Zettersten & Lupyan, 2018). The vocabulary range of children with DLD is narrower than that of their peers, and they experience problems with updating words and recalling them quickly, which might be reflected in their poorer performance during tasks that involve categorization.

The third research question was about qualitative differences in solving the tasks. The analysis of the execution of conceptual thinking shows differences between DLD and TD children in the number of correct answers provided in conceptual Thinking and in the way in which categories are ascribed. For instance, children with DLD refer to the functional attributes of objects more often than children in the TD group, however they consider the materials that the objects are made of less often. This might be caused by the fact that defining a material requires referring verbally to a category (e.g., metal, glass), whereas functional aspects refer to one's own perceptual and motor experiences.

The difference in answer distribution presented in Figure 1 is interesting as well. The category that was commonly recognized seems to have been simple and based on everyday experience: things that are associated with warmth (e.g., the sun, a lit candle, a stove) rather than cold (e.g., ice cream). However, one third of children with DLD (and less than 20% of children in the TD group) chose the sun as the odd element. One of the children with DLD commented that "słońce jest, a tamto są zrobione" ("the sun is, but that are made"). This statement, even though it is grammatically imperfect, carries an important implication. That is, the category adopted in this case is more abstract than the one adopted by the authors of the test, since it differentiates between man-made objects and natural ones. If one looks at the issue from this perspective, the sun is indeed different than the remaining objects, and the answer is valid.

The answers to the task in Figure 3 are also intriguing. TD children usually provided answers marked as correct in the key, indicating the figure that had reversed colors as the odd one. Meanwhile, children with DLD usually chose the only figure that has no axis of symmetry as the odd one. In this case, one might argue that this is a mistake in the test itself. Both answers are correct, each figure is, in a way, different than the others. However, the question arises as to why DLD children notice a feature such as the presence or absence of an axis of symmetry while they do not pay as much attention to the color arrangement. Possibly, difficulties in naming colors cause these children to focus on other aspects of the objects.

The theory of statistical learning disorders is considered to be one of the mechanisms underlying DLDs. A meta-analysis of 10 studies conducted by Lammertink et al. (2017) found a significant difference in the ability to detect regularity in nonverbal audio material presented in children and adolescents with DLD as compared to TD youth. Interlinguistic studies conducted by Chen et al. (2009) proved the significance of statistical learning processes and defining categories on the basis of linguistic material. Perhaps children learn to recognize categories in a similar manner, that is, by detecting rules hidden in the information that they collect from the environment via verbal channels. Children with DLD, having a limited ability to acquire the generally-used rules of categorization, create their own rules. Thus, they often select categories that differ from those chosen by TD children and also from the authors of the tests – but still logical. This possibility should be further investigated.

Conclusions

The present results confirm earlier reports showing that children with DLD do not perform as well as their peers in nonverbal tests. In a way, these results may reveal imperfections in the design of tests employed in intelligence assessment. Indeed, tasks that were intended to be nonverbal were found to be correlated with language functions. Thus, a well-developed language may assist a child in successfully solving such tasks and these tests may not be objective measures of intelligence among children suffering from DLD. On the other hand, the employed tools reflect mental processes that are based on language experience and are unique for the culture in which they were created and for the environmental expectations of the child. The different ways in which children with DLD solve tasks may represent a deficit, but may also be considered a source of originality. The categorization process in children with language impairment is worth further exploration.

Limitations

The study was conducted on a relatively small group. Due to SES, it is not representative of the population (although, on the other hand, the examined group's homogeneity makes it possible to control the influence of SES on language development). The research used tasks taken from the ABC II Kaufman battery. It would be helpful to use classification tasks specifically designed to analyze children's reasoning processes in the future. These could be tasks with more than one possible object classification category. The present study thus serves as a kind of pilot for deeper analyses.

Conflict of Interest Disclosure

The author declares no conflicts of interest.

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Research Ethics Statement

The study was approved by the Research Ethics Committee of the Faculty of Psychology of the University of Warsaw.

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