Research Paper

The Effect of Semantic Context on Lexical Access in Children With and Without Developmental Language Disorder

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ABSTRACT

Objectives: Lexical access problems are one of the limitations observed in children with developmental language disorders during the initial years of schooling. Semantic context has a powerful influence on lexical access. The cross-modal visual-auditory picture-word interference paradigm is a method for studying adults and children's lexical access. Because few studies have examined lexical access in Persian-speaking children, the present study aimed to investigate the effect of different semantic contexts on lexical access in children with and without developmental language disorder.

Methods: In this experimental study, 20 children aged 7-9 years with developmental language disorders and 20 age-matched peers were recruited according to the inclusion and exclusion criteria. At first, the picture-word interference paradigm was prepared. In so doing, 16 common pictures of objects paired with four auditory interfering words (related verb, related noun, unrelated verb, and unrelated noun) were presented to the children in a silent condition to determine their naming accuracy and latency. The DMDX software calculated the naming latency. The percentage of correct names also calculated naming accuracy.

Results: Naming latencies were significantly faster in children without language disorders ($P \leq 0.05$). In addition, a reliable interference effect was found. According to the results, naming latencies were significantly faster for related verb distractors than unrelated verbs and related noun distractors ($P<0.05$). In addition, a significant difference was observed between the silent and interference conditions regarding the naming accuracy. However, accuracy was not affected by distractors.

Discussion: Different semantic contexts affect lexical access differently in children. These differences cause semantic relatedness between verbs and nouns in lexical networks. The present study findings indicate that lexical knowledge and semantic relatedness are lower in children with developmental language disorders than in those with typical language development. These results can be useful for future studies and interventions on lexical access in children with and without language disorders.

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Highlights

• Lexical access is slower, with less accuracy in children with developmental language disorders than in peers.

• Different semantic contexts affected lexical access in children with and without developmental language disorders.

• Children's lexical knowledge and the type of semantic relatedness of words within the linguistic context could be affected by the level of interference in lexical access.

Plain Language Summary

Developmental language disorders (DLDs) result in significant and often lifelong problems in children. Lexical access and word-finding difficulties are common issues in children with DLD. The studies of naming skills in children with DLD in different languages indicate significantly slower and less accurate naming processes. In the present study, we revealed that different semantic interference could affect the accuracy and latency of lexical access in children with and without DLD. So, researchers and clinicians should be aware of semantic interference in their work with children and provide the appropriate context for tools or tasks according to the child's semantic knowledge. In the Persian language, it is useful to give some tools for various complex degrees of semantic relatedness. Difficulties in semantic relatedness also suggest that future investigations may identify areas of strengths and weakness in children with DLD in lexical access. Indeed, clinicians should use the naming latency in children's responses to determine the progress of lexical access intervention.

1. Introduction

Lexical access means selecting and retrieving a stored word from the mental lexicon [1]. Based on theories of word production, lexical access proceeds in two stages. The first stage is called lexical selection and involves the activation of semantic and syntactic properties of lexical items. The second stage, i.e. phonological encoding, consists of the activation of the phonological properties of lexical items [2, 3]. Word finding (WF) problem refers to a situation in which a person knows and understands a particular word but has difficulty retrieving and using it in their speech. WF difficulties are usually defined according to three measures: response time (RT), number of speech errors, and error patterns [4].

Developmental language disorder (DLD), previously known as specific language impairment, has also been used in research projects [5, 6]. It refers to the delay in language acquisition despite normal intelligence and emotional, social, and auditory functions. In addition, these individuals' language learning disabilities do not compensate until five years of age [7]. Many studies have focused on the difficulties related to morphology and syntax [8, 9], but few have been done on lexical access in DLD [10-12]. Evidence has revealed numerous differences between children with and without DLD with respect to WF abilities. For instance, children with DLD nominate pictures more slowly than those with typical language development (TLD) children [5, 10, 13]. They also produce significantly more errors in comparison with their TLD peers. However, children with DLD exhibit similar error patterns to those with TLD, with semantic errors predominating in both groups [10, 14-16]. These studies use offline techniques (e.g. analysis of naming errors or naming speed) to assess the end products of the WF process [10, 17]. Recent studies have also been designed to investigate the process of lexical access in children [18-20].

The cross-modal visual-auditory picture-word interference (PWI) paradigm is a useful method to evaluate the process of lexical access skills [18, 20, 21]. In this paradigm, people name target pictures as quickly and accurately as possible while ignoring the related and unrelated aurally presented distractor words that have a semantic or phonological relationship with the target picture or no connection with it. Speed and accuracy are analyzed for each condition [18]. Few studies have used a cross-modal PWI paradigm to assess the lexical access skills of children with DLD [18, 19]. For instance, Seiger-Gardner and Schwartz evaluated the lexical access of English-speaking children with DLD. The children with DLD produced a larger number of errors compared to their TLD peers; both groups exhibited a similar pattern of semantic and phonological effects. Thus, it was suggested that the children with DLD had similar para-

metrical lexical access to their TLD peers [18]. Moreover, Brooks, Seiger-Gardner, and Sailor used the PWI task to explore the effects of associate and coordinate relations in children (TLD & DLD) and adults. In children with DLD, lexical access gained weaker support from the networks of associations in semantic memory [19]. The studies for children have used the noun-noun interference paradigm, but the noun-verb interference has not been determined. Verb processing requires an understanding of relational concepts (transitive). Verbs are also semantically more complex. Thus, noun naming is more accurate and slower than verb naming in children with DLD [22, 23]. A study assessed the patterns of semantic interference with PWI in adults. In a part of that study, the participants were required to name the pictures of objects (e.g. "bed") in the context of semantically related verb distractors (e.g. sleep) and unrelated verb distractors (e.g. shoot). The results showed shorter naming latencies in the semantically related (verb) distractor condition compared with the unrelated verband noun distractors condition [24].

Regarding the findings of the studies about verb and noun interference and the amount of their relatedness in adults, our hypotheses are as follows: 1) the verbs interference is less than the nouns interference amongst children, and 2) the naming latency increase with the presence of the semantically related interference word. There are no studies about the effect of verb interference on lexical access in children with DLD. Therefore, the present study aimed to determine the effect of semantic context (verbs and nouns) interference on the accuracy and latency of lexical access in children with and without DLD and then the effect of semantic relatedness (related and unrelated verbs and nouns) interference on the accuracy and latency of lexical access in children with and without DLD.

2. Materials and Methods

The present study was conducted at the University of Social Welfare and Rehabilitation Sciences and was approved by the Ethics Committee of the University (Code: IR.USWR.REC.1394.223). The children's parents permitted their children's participation in the research by signing the informed consent forms.

Study participants

This experimental study was conducted on 40 children aged 7-9 years: 20 children with TLD (8 girls and 12 boys aged 7-9 years; Mean±SD 8.4±1.8 years) and 20 children with DLD (8 girls and 12 boys aged 7-9 years; Mean±SD 8.1±1.1 years). TLD children were selected via multistage sampling. At first, 15 public schools in Tehran, Iran, were randomly selected from three regions considering the socioeconomic status. TLD children were enrolled according to the inclusion criteria, i.e. being a monolingual native Persian speaker, lacking any language disorders, and being healthy with normal hearing, intelligence, sensory-motor, and visual abilities based on the child's health record at school. DLD children were selected by speech and language pathologists in the speech therapy centers based on the following inclusion criteria: being 7-9 years old at the time of testing, speaking Persian as their first language, having nonverbal intelligence within normal limits (80 and above) by using the Raven's colored progressive matrices test [25], Having language problem confirmed using the test of language development (TOLD-P:3) [26] and the Persian test of specific language impairment [27]. The DLD children should be scored at least 1.5 standard deviations below in the language test [28]. Also, they should not be shown evidence of visual, gross motor, emotional, attention, or neurological deficits based on the child's clinical record and lack of hearing impairments according to the pure tone audiometry test. The exclusion criteria were having obvious comorbid problems, including attention deficit and hyperactivity disorder (ADHD), and taking any medication such as psychiatric and neurological medications.

All DLD children were receiving speech therapy services, but they did not receive any specific intervention for lexical access. Eventually, 20 children were diagnosed with DLD.

Study stimuli

The visual stimuli were 18 black-and-white line drawings of common objects with high familiarity because studies show that high familiarity is more important than high frequency [29]. Familiarity also was one of the criteria for selecting the visual and auditory modalities and different tasks such as naming and lexical decision [30-32]. In this study, 16 pictures were selected as target pictures and two as practice pictures. The names of 11 objects in the pictures were monosyllabic, and the rest were two syllables. In addition, 34 familiar words served as interfering words (IWs). Besides, 32 stimuli were used with the target pictures, and two were used with the training items. Among these stimuli, 16 were nouns, and 16 were verbs. Among the IWs, nouns were selected from the Persian picture naming set [32] and verbs from the Persian action naming set [23]. In addition, 10 speech pathologists and linguistics selected these stimuli from

45 items. The target pictures were presented in 5 conditions for determining the naming accuracy and latency: with a related verb (pencil/writing), related noun (pencil/bag), unrelated verb (pencil/eating), unrelated noun (pencil/apple), and silent condition (pencil, without any IWs). The IWs were recorded by a female speaker and edited by Pratt software. This paradigm was entered into the DMDX software [33] to calculate the reaction time (RT).

Study procedure

The participants were tested individually in a quiet room in speech therapy centers. Before starting the experiment, the examiner presented a file to the participants, including all the pictures and their names to ensure that the children got familiar with them. The target pictures were presented on the center of a laptop screen. The IWs were also presented via headphones. The experiment began with the presentation of two training trials. The participants were asked to concentrate on the middle of the screen and name the picture as quickly and accurately as possible when it appeared. The DMDX software was utilized to record the RT. The pictures were presented to the children for 5000 ms with 1000-ms intervals. The stimuli were also presented randomly in five blocks, with the child receiving breaks between the blocks.

Statistical analysis

In this study, we used mixed model analysis of variance (ANOVA) for the mean RTs latency and naming accuracy of participants with 5 IWs (related verb, related noun, unrelated verb, unrelated noun, and silent condition) as within-subject variables×2 groups (DLD and TLD) as the between-subject variable.

3. Results

This experiment focused on the effects of semantic context in children with and without DLD in the PWI task.

The descriptive analysis of the language ability of children with DLDs is presented in Tables 1 and 2.

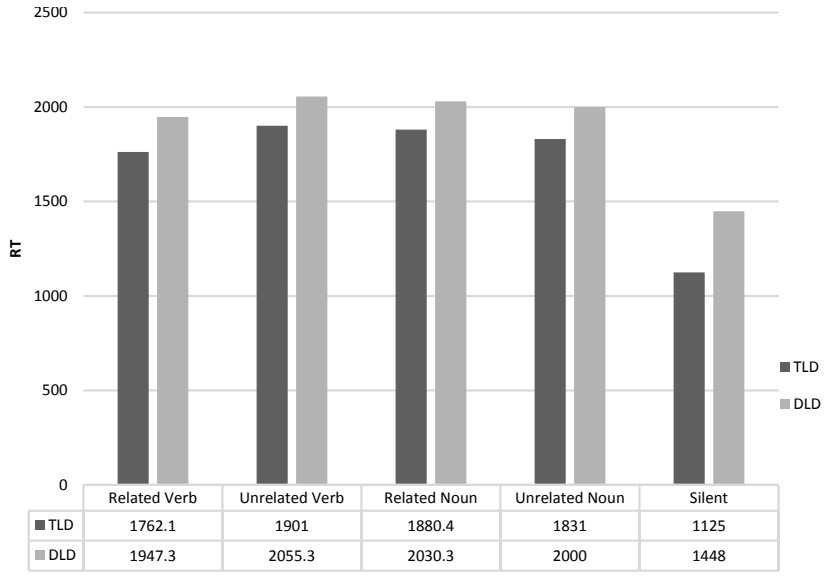
For analyzing the RTs, we applied the mixed model analysis of variance (ANOVA). The responses that differed from the expected names, dysfluencies, recording failures, and outliers (5000 ms≥ reaction times ≤500 ms) were excluded from the analysis. Descriptive methods were used for expressing accuracy and RT. The mean RTs for the two groups' correct responses (TLD and DLD) under each IW type (related noun, unrelated noun, related verb, unrelated verb, and silent) are depicted in Figure 1.

Table 1. Mean±SD scores of test of language development (TOLD-P:3) in children with developmental language disorders

	Mean±SD						
Age (y)	Picture Vocabulary	Oral Vocabulary	Grammatical Understanding	Sentences Imitation	Grammatical Completion	Word Discrimination	Word Articulation
7-8	18.02±4.1	12.55±4.31	15.94±4.34	12.95±6.76	10.54±7.87	12.65±3.78	16.89±1.99
8-9	19.34±4.65	16.02±5.66	16.59±6.90	15.65±4.60	12.01±5.65	15.63±3.69	17.11±4.84

Table 2. Mean±SD scores of the Persian test of specific language impairment in children with developmental language disorder

	Mean±SD								
Age (y)	Repetition	Syntax Comprehension	Vag Test	Auditory Comprehension	Verbs Tense	Grammatical Judgment	Pointing	Derivative Morphemes	Grammatical Correction
7-8	9.82±1.2	8.45±2.3	7.21±3.87	7.65±1.34	5.1±2.84	5.9±4.34	9.94±1.45	3.1±4.21	3.41±1.51
8-9	10.31±1.24	8.98±2.31	7.91±3.19	8.21±2.19	5.95±2.41	6.74±3.4	9.98±1.13	3.78±2.45	4.56±2.51



	Related Verb	Unrelated Verb	Related Noun	Unrelated Noun	Silent
TLD	1762.1	1901	1880.4	1831	1125
DLD	1947.3	2055.3	2030.3	2000	1448

Figure 1. Mean reaction time (RT) for correct responses for each group under each IW type

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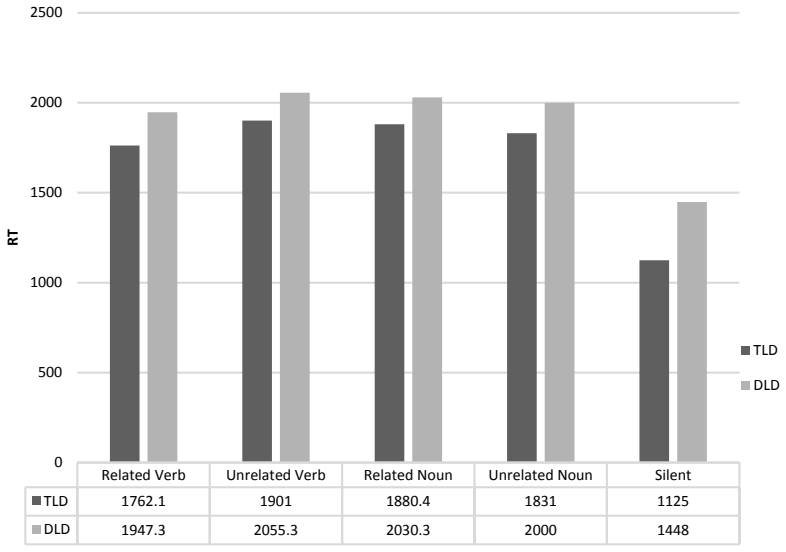
In this study, two bivalent variables were analyzed: The semantic context of the distractor word (noun vs verb) and relatedness (related vs unrelated). Both variables were evaluated within the study groups, as well. Moreover, mixed model ANOVA was conducted on the participants' RTs, with 5 IWs (related verb, related noun, unrelated verb, unrelated noun, and silent condition) as within-subject variables×2 groups (DLD and TLD) as the between-subject variable. The results showed significant main effects for the five IW conditions ($F_{4,124}$=92.4, P≤0.001, partial η^2=0.75). The results of the Bonferroni post hoc test also revealed that the mean RT was significantly higher in the silent condition than in the other conditions (P≤0.01). In addition, a significant difference was observed between the mean RTs in the related verb interference condition and the unrelated verb interference condition (P≤0.03), as well as in the related verb interference condition and the related noun interference condition (P≤0.03). There were also significant differences within each group (DLD and TLD) in this regard ($F_{4,124}$=11.96; P≤0.01, partial η^2=0.28). The Mean±SE RT values were 1896±45.82) in the DLD group and 1693±36.94 in the TLD group. Finally, the interaction between the type of distractors and children's disorder had no significant effects on the naming latency ($F_{1, 31}$=1.67; P≥0.21, partial η^2=0.05).



	Related Verb	Unrelated Verb	Related Noun	Unrelated Noun	Silent
TLD	1762.1	1901	1880.4	1831	1125
DLD	1947.3	2055.3	2030.3	2000	1448

Figure 2. The mean number of naming errors in five conditions for each group of children

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Naming errors

The means of naming errors in the five conditions were calculated for each group of children and were analyzed by mixed model ANOVA.

The mean number of naming errors was higher in the children with DLD compared to those with TLD in all the conditions, and the results of the independent t-test showed that this difference was statistically significant (P≤0.05) (Figure 2).

The results revealed significant main effects for the IW conditions (within-subject variable) ($F_{4, 160}$=5.05, P≤0.001, partial η^2=0.11). The results of the Bonferroni post hoc test (P≤0.5) indicated that the mean number of naming errors was significantly higher in the silent condition than in the unrelated verb IW (P≤0.01), related noun IW (P≤0.001), and unrelated noun IW (P≤0.00). If the silent condition had not been calculated in this part, it could have been demonstrated that the IW did not significantly affect the number of naming errors (P≥0.05).

Considering the between-subject group effect, the language disorder affected the number of naming errors among the children ($F_{1, 40}$=107.77, P≤0.00, partial η^2=0.44). Based on the results, the children with and without DLD were significantly different regarding the mean number of naming errors (Mean±SE 0.12±0.01 vs Mean±SE 0.03±0.01). However, the interaction between the type of distractors and the children's disorder had no significant effects on the naming accuracy ($F=_{1.6}$; P≥0.21).

4. Discussion

This study aimed to assess the effects of semantic context on lexical access in children with and without DLD using a PWI. Children with DLD have significant lexical and semantic deficits that affect their lexical access. Therefore, this study sought to clarify the nature of their difficulties by exploring how different types of contexts influence lexical access in PWI tasks. The naming accuracy and latency in the interference conditions were higher in the TLD children than in the DLD children. In addition, the type of interference condition affected naming accuracy and latency differently. However, the 2-way interaction (interference and disorder) had no significant effects on the naming accuracy and latency.

The results indicated that the context of the target word and IW (noun-noun) result in a higher naming latency. Other studies also demonstrate a higher interference when the target word and the IWs are in the same context (verb-verb) compared with different contexts (verb-noun) [24, 34].

In the present study, both groups of children revealed a faster naming latency in the presence of related verb interference (bed, sleep) than unrelated (bed, washing). This finding was similar to that obtained in the research carried out by Mahon using a PWI paradigm [24]. This result may be explained by the fact that not all semantic relations cause the same semantic interference. When the related verb is used as interference, there is no direct semantic relationship. The previous studies used nouns as IWs, and the target stimuli indicated that the related IWs resulted in the activation of the related lexical nodes and activated the related convergent lemmas. Therefore, selecting target words among the convergent lemma became difficult [35]. Nevertheless, the lexical nodes of the related verb interference might be located at a higher activation level than the unrelated verb interference. Yet, it had lower interference effects [24]. Another possible reason for the differences in the results could be the differences in the types of relationships. An associative relation between words (such as noun-verb) decreases the effect of convergent activation [36]. The relationship between nouns and verbs is not one by one and is like an associative relation [24].

Similar to the research carried out by Mahon and collogues, the present study results revealed faster lexical access latency in the presence of the related verb interference compared to the related noun interference. Generally, more lexical competitors are activated, and the speed of lexical access is reduced in the presence of the related noun interference (coordinated relation) [24]. Overall, different types of WI create a degree of semantic constraints. For example, objective words have a higher competition with target words compared with abstract words. Thus, concrete words possibly create more interference in comparison to abstract words. Since nouns are more objective than verbs, they generate more interference [24, 37].

The current study findings showed that naming latency in the presence of a related noun distractor was slower than unrelated. When the IW and the target word belong to the same category (such as bee and horse), convergent activity occurs, and the lexical nodes of same-category coordinate nouns are activated. This results in convergent activation and creates more lexical competition [38]. The present study results also demonstrated that using the related noun interference was accompanied by increased naming latency.

Based on neuroscience, lexical processing in the human brain leads to different results in terms of verb and noun IWs [39, 40]. Studies on people with brain damage have documented differential patterns of neural activity. They also found different activities in the temporal lobe during noun expression. On the other hand, difficulty in expressing verbs might be associated with damage to the left frontal lobe [40].

The present study results revealed no significant difference between the children with and without DLD regarding naming accuracy in different types of PWI tasks. These results agreed with the research performed by Brooks et al. Furthermore, some researchers believed that semantic context had lower effects on lexical access amongst children with DLD due to their small lexicon and weak semantic representation compared to their peers with typical development [14, 19]. However, we should be aware of this interpretation because some evidence shows that declarative memory correlates with lexical abilities in children with DLD [41, 42]. Therefore, understanding the main cause of the problem requires further research.

5. Conclusion

Assessment of different types of semantic interference revealed that different contexts of interference and language disorders could affect the children's lexical access. Besides, interference leads to lower accuracy and latency of lexical access in children with developmental disorders. Studies in various semantic contexts can play a critical role in evaluating and treating language disorders and lexical access.

In the present study, some limitations must be considered before generalizing the results. First, this research was done only on 20 children with DLD; it is better to confirm the results for larger sample size and other age ranges. Second, we compared the DLD children with chronological age-matched peers, and further research needs to be conducted to compare the DLD children with language-matched and vocabulary-matched peers.

Ethical Considerations

Compliance with ethical guidelines

The authors certify that they have no affiliation with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials dismissed in this manuscript. (Code: IR.USWR. REC.1394.223).

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Authors' contributions

Conceptualization, resources, funding acquisition, and methodology: Fatemeh Hassanati, Reza Nilipour, and Zahra Sadat Ghoreishi; Analysis, investigation, and writing the original draft: Fatemeh Hassanati; Writing, review, and editing: Fatemeh Hassanati, Zahra Sadat Ghoreishi, Salime Jafari, and Zahra Sadeghi; Supervision: Reza Nilipour and Zahra Sadat Ghoreishi.

Conflict of interest

The authors declared no conflict of interest.

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