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BRIEF REPORT

Abilities of children with language developmental disorders in perceiving phonological, grammatical, and semantic structures

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Abstract

This study aims to investigate the perception of phonological, grammatical, and semantic structures by 8 children (age range: 8;2–9;5) with developmental language disorders (DLD). Another 8 age-matched (age range: 8;4–10;0) typically developing (TD) children served as controls. The results demonstrated that children with DLD had lower performance than children with TD in the phonology and grammar tests, corroborating earlier findings, which reported difficulties of children with DLD in discriminating voicing contrasts and perceiving grammatical structures. However, both groups had similar performance in the semantic test. The absence of semantic atypicality can be explained possibly due to the simplicity of the sentences included in the test. The study offers important clinical implications for the identification and treatment of the disorder.

Keywords Perception · Phonology · Grammar · Semantics · DLD

Introduction

Children with developmental language disorders (DLD) encounter more difficulties in both perceiving and producing expressive/receptive oral language compared to their age peers in the absence of any hearing, neurological, or cognitive impairments (e.g., low IQ performance) (Bishop & Leonard, 2014; Kidd et al., 2017; Rice, 2013). These difficulties are present in every language domain including phonology (e.g., Jackson et al., 2019), morphology (e.g., Kueser et al., 2018), syntax (e.g., Sasaki et al., 2021), semantics (e.g., Mainela-Arnold et al., 2010), and pragmatics (e.g., Narayanan et al., 2021) and impact both the perception (i.e., identification/discrimination) and production of language (i.e., articulation). The present study focuses on the investigation of the language perceptual abilities of children with DLD, which have received less scientific attention compared to production abilities, with emphasis on the domains of phonology, grammar, and semantics.

Phonological processing is often atypical in children with DLD, as they present with poor speech perceptual abilities and strong difficulties in the identification, discrimination, and categorical perception of sounds or sound features (Collet et al., 2012; Ziegler et al., 2011; Quam et al., 2021; Stark & Heinz, 1996). For example, Quam et al., (2021) found that 4-5-year-old English-speaking children with DLD less successfully mapped pitch categories to meanings and had lower sound discrimination scores than children with TD. Evidence from different native languages demonstrates challenges of children with DLD as compared to neurotypical children in the processing and comprehension of several grammatical aspects including subject-verb agreement (Dube et al., 2019), tense and aspect (Duman & Topbaş, 2016; Leonard & Deevy, 2010), *wh*-questions (van der Lely et al., 2011), and relative clauses (De López et al., 2014; Montgomery, 2000; Talli & Stavrakaki, 2020) among other. For instance, Talli & Stavrakaki (2020) concluded that monolingual Greek children with DLD with an average age of 8;11 experienced difficulties in comprehending subject-object relative clauses compared to their TD peers. In addition, research in children with DLD shows difficulties in semantic and lexical processing (for English, see Haebig et al., 2017; for French, see Leclercq et al., 2014) and poor

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understanding of multiple word meanings and/or confined vocabulary (Bishop et al., 2017).

The aim of this study is to investigate the perception of linguistic structures belonging to the domains of phonology, grammar, and semantics by Cypriot Greek-speaking children with DLD. Children's abilities were compared with those of age-matched typical peers. To our knowledge, this is the first study that examines the language perception skills of Cypriot Greek children with DLD. Previous work has focused mostly on the children's production skills and was confined to grammar (e.g., Theodorou & Grohmann 2015; Kambanaros, 2014). Further research in Cypriot Greek speakers with DLD will not only allow us to provide better assessment and treatment to these speakers, but it will also let us know which difficulties are found only in Cypriot Greek and which are found in similar structures of other languages in an attempt to design an assessment tool that can be used in several languages. The experimental protocol of this study was based on two-alternative forced-choice tasks conducted on a personal computer (PC). These tasks required children to choose one of the two responses on the PC, after listening to the auditory stimulus. The study is expected to provide useful insights into the identification of difficulties in the perception of phonological, grammatical, and semantic structures, contributing to the treatment of these language difficulties.

Methods

Participants

Two groups of Cypriot Greek-speaking children participated in the study: one group of 8 typically developing children (TD) with an age range of 8;4–10;0 (M_{age} = 9;3, SD = 0;7) and one group of 8 children with language developmental disorders (DLD) with an age range of 8;2–9;5 (M_{age} = 8;8, SD = 0;5). The two groups were matched for chronological age [$t(14)$ = -1.81, p = 0.09] and IQ [$t(14)$ = -2.06, p = 0.06] (Raven's Colored Progressive Matrices test; Raven et al., 2003). Initially, speech and language therapists diagnosed those individuals based mostly on their clinical judgments, and our team then confirmed the diagnosis using the Diagnostic Verbal IQ test (DVIQ) (Stavrakaki & Tsimpli, 2000). DVIQ measured children's vocabulary, morphosyntactic, and recall skills. Table 1 presents the individual characteristics of the participants.

Table 1 Participants' individual characteristics

Code	Group	Age	IQ	Language scores (V; M; R)*
FP	TD	8;4	90	V: 27/27; M:22/23; R: 48/48
MC	TD	8;6	125	V: 25/27; M:22/23; R: 48/48
MC2	TD	8;8	85	V: 24/27; M:23/23; R: 48/48
AS	TD	9;4	105	V: 24/27; M:19/23; R: 46/48
FP2	TD	9;10	115	V: 25/27; M:21/23; R: 48/48
SD	TD	10	115	V: 25/27; M:22/23; R: 48/48
OP	TD	10	105	V: 24/27; M:20/23; R: 48/48
ML	TD	10	90	V: 25/27; M:18/23; R: 48/48
IL	DLD	8;2	80	V: 21/27; M:10/23; R: 44/48
MC3	DLD	8;3	80	V: 20/27; M:16/23; R: 39/48
GI	DLD	8;4	85	V: 23/27; M:15/23; R: 41/48
LK	DLD	8;5	75	V: 18/27; M:7/23; R: 36/48
EM	DLD	9	100	V: 19/27; M:15/23; R: 46/48
MV	DLD	9;3	120	V: 24/27; M:16/23; R: 45/48
PM	DLD	9;3	90	V: 21/27; M:13/23; R: 46/48
KP	DLD	9;5	80	V: 19/27; M:17/23; R: 47/48

*V = vocabulary; M = morphosyntax; R = recall

Stimuli

One adult Cypriot Greek speaker was used to record the stimuli for all language measures. For the purpose of the phonology test, the speaker produced ten Cypriot Greek consonants: 5 fricative/stop voiced consonants [b d g v z] and their voiceless counterparts [p t k f s] embedded in trisyllabic /CCV.CV.CV/ (C = consonant, V = vowel) nonsense words, which corresponded to the phonotactics of real words. The target sounds were part of consonantal clusters. In addition, the speaker produced the stimuli of the grammar and the semantic tests with a normal speaking pace as speaking to a friend. The sentences in both tests had a similar structure. They started with "Everyday" and then continued with an action depending on the target grammatical/lexical item under investigation (e.g., "Everyday, I eat the food I like"). The productions of the speaker were recorded at a 44.1 kHz sampling rate.

Procedure

The children completed a phonology, grammar, and semantic test in quiet rooms. All tests were performed on a computer-based Praat script (Boersma & Weenink, 2021) and were completed within an hour (range: 30–60 min; average: 45 min). Prior to each main test, children completed 4-trial familiarization tests, which included different items from the main tests.

The phonology task was an AX discrimination test. The participants listened to a pair of target words through a set of headphones and they were asked to select whether these words were the same or different by clicking through the mousepad on the relevant script label. The children discriminated a total number of 20 consonants each, which consisted of 10 "same" trials (5AA, 5BB) and 10 "different" trials (5AB, 5BA). The interstimulus interval was 700 m.s (following Georgiou 2021). The grammaticality judgment

test asked participants to judge whether different sentences that were heard from the PC loudspeakers were syntactically correct or not by clicking on the relevant label. There were three different subtests: (a) a subject-verb agreement test, (b) a clitic test, and (c) a *pu*-relative clause test, which were included in a single test. Each child judged 30 sentences (5 correct and 5 wrong sentences for each subtest: e.g., "Every day, the dog *plays/play** in the garden"). The participants also completed a semantics judgment test. The protocol was similar to that of the grammar test but, instead, in this test, they were called to identify if different sentences were semantically correct or not. Each child judged 20 sentences (5 correct and 5 anomalous verbs: e.g., "Every day, the phone *rings/runs** for a long time", and 5 correct and 5 anomalous nouns: e.g., "Every day, Helen reads the *newspaper/image**"). The stimuli of all tests were automatically presented in random order and there was an optional two-minute break.

Statistical analysis

We fitted a *binomial logistic mixed-effects model* in R (Bates et al., 2021). *Response* was the dichotomous dependent variable, *test* (phonology, grammar, semantics), *group* (TD, DLD), and *test* × *group* were the fixed factors and *participant* was the random factor.

Table 2 Results of the binomial mixed-effect model

	response				
Predictors	*Estimate*	*Std. Error*	*z value*	*Pr(>|z|)*	
(Intercept)	1.257011	0.181252	6.935	4.06e-12	***
test [phonology]	-0.239098	0.237412	-1.007	0.313886	
test [semantics]	0.361988	0.262810	1.377	0.168396	
group [TD]	1.011645	0.298866	3.385	0.000712	***
test [phonology] * group [TD]	-0.002337	0.405374	-0.006	0.995400	
test [semantics] * group [TD]	-0.261335	-0.442161	-0.591	0.554494	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Results

The results showed that there was a significant effect of group ($\beta = 1.01$, $SE = 0.3$, $z = 3.39$, $p < 0.001$). The results of the model are illustrated in Table 2. To investigate further this effect, we used pairwise comparisons with the *emmeans* package (Lenth et al., 2021). The *Tukey* posthoc test demonstrated that children with TD performed significantly better than children with DLD in the phonology (M_{TD} = 88.1%, M_{DLD} = 73.1% correct responses) (β = -1.01, $SE = 0.3$, z = -3.39, $p = 0.009$) and in the grammar tests (M_{TD} = 90.4%, M_{DLD} = 77.5% correct responses) (β = -1.01, $SE = 0.33$, z = -3.06, $p = 0.027$), but the performance of the two populations in the semantic test did not differ (M_{TD} = 90.2%, M_{DLD} = 83.1% correct responses) (β = -0.75, $SE = 0.38$, z = -2.00,

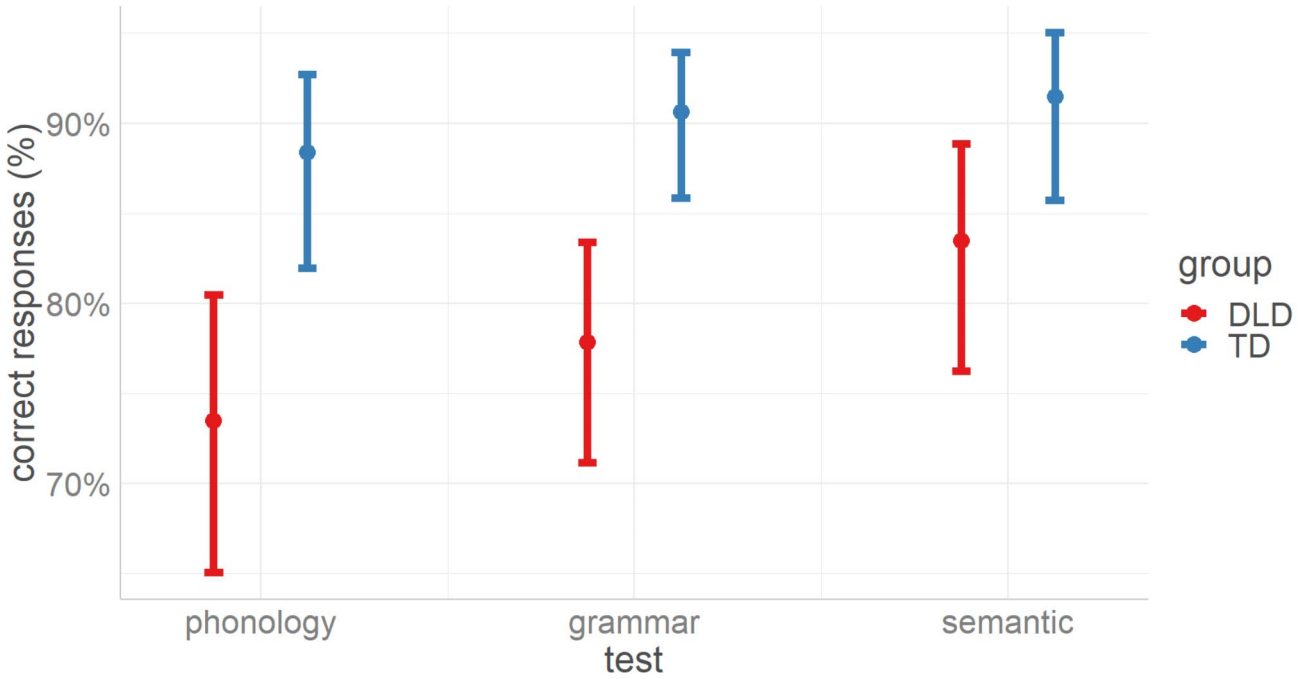

Fig. 1 Predicted probabilities of correct responses in the three tests by children with DLD and TD

$p = 0.34$). Figure 1 shows the predicted probabilities of correct responses in all tests by children with DLD and TD.

Discussion

The study examined the abilities of children with DLD in the perception of phonological, grammatical, and semantic structures of their native language. Their responses were compared with those of age-matched typical peers. The results yielded that children with DLD are characterized with difficulties in the perception of phonological and grammatical structures, but their abilities in the perception of semantic structures were typical.

Specifically, in the phonology test, children with DLD experienced challenges in the discrimination of voiced vs. voiceless consonants found in clusters. This corroborates the earlier findings of Collet et al., (2012) and Ziegler et al., (2011) who observed difficulties of French-speaking children with DLD in discriminating voicing contrasts. Although the peripheral and central auditory systems of children with DLD perform well in the encoding of acoustic information, their auditory system is characterized as incomplete with respect to the mapping of acoustic information onto phonetic features which allows phonological recognition (Ziegler et al., 2011).

The results of the grammar test are consistent with those of other studies which investigated the comprehension of subject-verb agreement (Kosteletou-Kassotaki et al., 2017), clitics (Chondrogianni et al., 2015), and relative clauses (Talli & Stavrakaki, 2020) in other Greek-speaking populations (i.e., Standard Modern Greek speakers), although these studies employed different methodologies (e.g., self-paced listening tasks, syntactic comprehension tasks, etc.). They also agree with the findings of other studies that examined the comprehension of grammatical structures such as relative clauses, subject-verb agreement, and clitics by DLD populations with other native languages (e.g., for Danish, see De López et al., 2014; for English, see Dube et al., 2019; for Spanish, see Girbau et al., 2017), suggesting that these structures are also difficult for speakers with other native language backgrounds. Such a conclusion might be explained through the tenets of generative grammar (Chomsky, 1957) as the existence of linguistic universals might be responsible for the common difficulties among speakers with different native languages.

Surprisingly, the perceptual ability of semantic structures by children with DLD, namely, sentences that involve anomalous verbs and nouns, was not atypical. Typical semantic components were found by Arosio et al., (2017) as children with DLD did not experience any problems with the semantic component associated with the meaning of quantifiers. However, the results do not agree with those presented in a significant body of studies (e.g., Haebig et al., 2017; Leclercq et al., 2014; Van–Alphen et al., 2021) and which report atypical semantic processing and comprehension in populations with DLD. Perhaps, the fact that the sentences of the semantic test in our study had a simple structure caused no problem to children with DLD, considering that challenges are mostly found in the process of complex sentences (Montgomery & Evans, 2009). Further research is needed to examine how these children process more complex semantic structures.

The study can offer clinical implications. The observation of perceptual abilities at various language domains might serve as a criterion for the identification and classification of DLD using an assessment tool. Also, the results can be used as a reference point to develop the appropriate clinical therapies. Evidence about the nature of the difficulties with respect to the perception of specific language structures by children with DLD will allow clinicians to target these difficulties and consequently treat them. Finally, the findings of this study demonstrate that the difficulties of children with DLD in the structures under investigation are also apparent in similar structures found in different languages (e.g., Danish, English, Spanish). This might allow researchers to create an assessment tool that can be used in several languages.

Limitations

This work is part of a larger research project, offering some preliminary findings regarding the perception of language structures by children with DLD. Therefore, a limited number of participants was recruited. Also, gender differences were not considered in this study.

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Conflict of interest We have no conflicts of interest to disclose.

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