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RESEARCH REPORT

Difference in Language Profiles of Children With Autism Spectrum Disorder and Down Syndrome Is Not Driven by Non-Verbal Cognition

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) and Down syndrome (DS) are among the most common types of neurodevelopmental conditions that have co-occurring language impairments. Usually, non-verbal IQ has been reported as one of the main predictors of language functioning in children with these conditions. Although language abilities of children with ASD and DS have been described in the previous studies, there is still a lack of direct comparisons of language profiles in the non-verbal IQ-matched groups of children with these disorders, and, therefore, it is largely unexplored whether language difficulties in these populations are of similar or different origins.

Aims: The study provided a direct comparison of language profiles in non-verbal IQ-matched children with ASD and DS at different linguistic levels (phonology, vocabulary and morphosyntax) in both production and comprehension and explored the influence of different psycholinguistic variables on accuracy. Also, the study assessed whether non-language factors (non-verbal IQ and age) influence language skills in both groups of children.

Methods and Procedures: In total, 60 children participated in the study: 20 children with ASD, 20 children with DS and 20 typically developing controls (7–11 years old; all groups were age-matched). The language testing included seven tests from the Russian Child Language Assessment Battery, assessing expressive and receptive language skills at phonological, lexical and morphosyntactic levels.

Outcomes and Results: Overall, we revealed both similarities and differences in language profiles between children with ASD and DS. At the group performance level, children with ASD and DS were comparable in vocabulary and syntax but differed in phonological processing, on which children with ASD had higher accuracy. Some psycholinguistic variables that influenced accuracy in language test performance were present uniquely in the ASD group: for example, autistic children struggled more with verbs than nouns in naming or comprehended sentences with canonical SVO word order more accurately than sentences with noncanonical OVS word order. In comparison to children with DS, in the ASD group, non-verbal IQ was related to language skills in three out of seven tests, with evidence of a positive association between them.

Conclusions and Implications: This study provided new insights on the differences in language profiles of non-verbal IQ-matched children with ASD and DS and identified specific impairments related to linguistic levels and structural language characteristics in each group. These findings contributed to speech and language therapy strategies, as they highlighted specific 'linguistic deficits' that should be targeted during intervention and therapy.

WHAT THIS PAPER ADDS

What is already known on this subject

- Language profiles of children with Autism Spectrum Disorder (ASD) and Down syndrome (DS) have been described in previous studies on different languages. Usually, non-verbal IQ has been reported as one of the main predictors of language functioning in these groups of individuals with neurodevelopmental disorders. However, there is a lack of direct comparisons of language profiles at different linguistic levels in these groups, matched by non-verbal IQ and using standardized language assessment tools to understand whether the nature of language impairments is common or different in ASD and DS regardless of non-verbal cognition.

What this study adds to the existing knowledge

- This study provided a direct comparison of language profiles at different linguistic levels in children with ASD and DS matched by non-verbal IQ. This identified similarities and differences in language functioning at different linguistic levels in children with ASD and DS as well as revealed non-language factors that were associated with language abilities.

What are the potential or actual clinical implications of this work?

- The study showed the differences in language profiles of children with ASD and DS regardless of non-verbal IQ and identified specific impairments related to linguistic levels and structural language characteristics. This knowledge contributes to speech and language therapy strategies, as it elucidates specific 'linguistic deficits' that should be targeted during intervention and therapy.

1 | Introduction

Autism Spectrum Disorder (ASD) and Down syndrome (DS) are among the most common neurodevelopmental conditions that have co-occurring language deficits (Arutiunian et al. 2022; Næss et al. 2011; Roberts, Price, and Malkin 2007). However, little research has been conducted to investigate whether language impairments in children with ASD and children with DS are distinct or share similar features. We believe that a direct comparison of language profiles in children with ASD and those with DS will provide the insights into whether the language difficulties in these populations stem from similar or different origins.

1.1 | Language Abilities of Children With ASD

Although language impairment is not among the core symptoms of ASD, about 75% of children with this disorder have co-occurring language difficulties (e.g., Kjelgaard and Tager-Flusberg 2001). Previous studies have demonstrated that language skills of children with ASD are highly heterogeneous (from completely nonverbal or minimally verbal to typical language functioning) and may differ depending on a linguistic level and expressive/receptive domain (Arutiunian et al. 2022; Girolamo et al. 2023; Kwok et al. 2015). Recent studies have revealed that language impairments in children with ASD can be due to both linguistic and non-linguistic/pragmatic issues, including more domain-general processes such as statistical learning (e.g., Eigsti et al. 2011) and altered interconnection between language abilities, theory of mind and cognitive skills as well as executive function (e.g., Abd El-Raziq et al. 2025; Schaeffer et al. 2023). Summarizing the previous findings, Schaeffer et al. (2023) have suggested that the main language profiles in children with ASD can be established as (1) ASD with normal language functioning, (2) ASD with language impairments and (3) minimally verbal/nonverbal ASD. In the groups of autistic children with language impairments, the difficulties are highly variable and affect all linguistic levels. At the phonological level, atypicalities were observed in phonological awareness and speech sound processing (e.g., Williams et al. 2013). At the level of vocabulary, most children with ASD have difficulties in single-word production and comprehension, with more difficulties with verbs in comparison to nouns, although it is the least impaired linguistic level in ASD (e.g., Arutiunian et al. 2022; Kjelgaard and Tager-Flusberg 2001; Kover et al. 2013; Swensen et al. 2007). At the level of morphosyntax, most children with ASD were reported to have difficulties in morphological and syntactic processing (e.g., Eigsti et al. 2007; Kover et al. 2014; Wittke et al. 2017). Specifically, linguistic features, such as sentence length, word frequency in sentences and word order, influenced accuracy: short sentences were repeated more accurately than long sentences, sentences with high-frequency words were produced more accurately than with low-frequency words and sentences with canonical Russian subject-verb-object (SVO) word order were comprehended more accurately than sentences with noncanonical object-verb-subject (OVS) word order (Arutiunian et al. 2022).

1.2 | Language Abilities of Children With DS

DS is a genetic condition associated with intellectual disability. Although in most cases individuals with DS have overall language delay and impairments in comparison to typically-developing (TD) controls, their language profiles are also heterogenous, with some aspects of language being comparable with neurotypical peers (e.g., narrative language abilities; see Mattiauda et al. 2022). Overall, despite heterogeneity, most children with DS usually demonstrated deficits in phonological processing (Abbeduto et al. 2007; Næss et al. 2011). At the level of morphosyntax, children with DS usually struggle more with expressive than receptive syntax (Abbeduto et al. 2007), with the evidence of the difficulties in morphology in both domains (Chapman et al. 2002; Fowler 1990; Miolo et al. 2005). All these difficulties in expressive language are usually explained by the specific impairment in the phonological loop (Buckley and Le Prèvost 2002; Jarrold et al. 1999), and some studies have suggested that phonological and syntactic deficits are a particular feature of children with DS (Fowler 1990; Næss 2016; Roberts, Price, and Malkin 2007). In comparison to other linguistic levels, vocabulary (especially word comprehension) is relatively intact. Word production is usually more delayed than word comprehension (Abbeduto et al. 2007; Laws and Bishop 2003; Roberts, Price, and Malkin 2007), and the accuracy is higher for nouns in comparison to verbs across both domains (Chapman 2003; Witecy and Penke 2017).

1.3 | Comparisons Between Language Profiles in ASD and DS

The direct comparisons of language abilities in children with ASD and DS are very few in number and also report contradictory evidence. For example, Koizumi et al. (2020) found that receptive syntax with a simple sentence structure as well as expressive morphology were more developed in children with ASD than in children with DS (see similar conclusions in Udhnani et al. 2020). On the contrary, Martin et al. (2018) reported that children with ASD had more impaired language comprehension skills compared to children with DS. Finally, Roberts, Price, Barnes, et al. (2007) showed no difference between children with DS and Fragile X Syndrome with ASD in lexical comprehension, whereas in production, children with DS were reported to have poorer word production skills in comparison with children with Fragile X Syndrome with ASD. As a result, it is largely unknown whether children with neurodevelopmental disorders of different aetiology (ASD and DS) and co-occurring language impairments have similar or different language profiles.

1.4 | The Influence of Non-Verbal IQ and Age on Language Skills

Individual differences in age and non-verbal IQ can influence children's performance in language tests. Some studies demonstrated this connection in children with ASD and DS (e.g., Arutiunian et al. 2021, 2022; Roberts, Price, Barnes, et al. 2007; Udhnani et al. 2020).

Non-verbal IQ has been reported as one of the main predictors of language skills at different linguistic levels in children with ASD and DS, although it cannot explain the whole heterogeneity of language profiles. For example, for children with ASD, Kjelgaard and Tager-Flusberg (2001) have found a significant association between non-verbal IQ and different language skills, suggesting that non-verbal IQ, at least partly, can account for the heterogeneity in language functioning in children with ASD. The same association has been identified in a group of younger children with ASD (Nevill et al. 2019) as well as in primary-school-aged children with ASD at different linguistic levels (Arutiunian et al. 2022) and in expressive and receptive domains (Arutiunian et al. 2021). Similarly, for children with DS, Udhnani et al. (2020) have reported that non-verbal IQ predicted language skills at the levels of phonology, semantics, morphology and syntax. Finally, the study of Roberts, Price, Barnes, et al. (2007) has demonstrated that children with DS showed a stronger correlation between their expressive vocabulary and non-verbal IQ in comparison to children with Fragile X Syndrome with ASD.

As for the relationship between chronological age and language skills at different linguistic levels in expressive and receptive domains, most of the previous studies in ASD have not shown that association (e.g., Arutiunian et al. 2022). In individuals with DS, the association with chronological age has been identified only at the level of vocabulary, with evidence of better performance in older children (Pennington et al. 2003).

1.5 | The Present Study

The present study compares language profiles in non-verbal IQ-matched children with ASD and DS at different linguistic levels (phonology, vocabulary and morphosyntax) in the domains of production and comprehension. First, we aim to compare language abilities of children with ASD and DS and to assess the influence of different psycholinguistic variables on their performance accuracy to reveal similarities and differences in language profiles that are not driven by non-verbal cognition. Second, in each group we aim to assess the association between age and non-verbal IQ and children's language skills. The study is novel, as it uses a comprehensive formal language assessment to compare the groups of children with two different neurodevelopmental disorders. We believe that it will help to explore specific language features in ASD and DS that are not driven by the overall level of cognitive development.

2 | Methods

2.1 | Participants

Overall, 60 native Russian-speaking children participated in the study: 20 children with ASD (4 girls, age range 7.02–11.02, M_{age} = 8.5, SD = 1.1), 20 children with DS (14 girls, age range 7.00–10.06, M_{age} = 8.7, SD = 1.2) and 20 TD controls (7 girls, age range 7.06–11.03, M_{age} = 8.9, SD = 1.2). The three groups of participants were age-matched but differed in sex distribution, with a higher proportion of boys in the ASD group than in the other two groups. Socioeconomic status (SES) was not measured directly in this study. All children lived in Moscow and were recruited from state schools or received education and therapy in specialized institutions.

Children with ASD were recruited from the Federal Resource Center for Organization of Comprehensive Support to Children with Autism Spectrum Disorders (Moscow, Russia). All of them had a clinical diagnosis within the autistic spectrum, based on the International Classification of Diseases, ICD-10, and all of them were also assessed by a licensed psychiatrist with the Autism Diagnosis Observation Schedule—Second Edition, ADOS-2 (Lord et al. 2012). Exclusion criteria were the presence of a known chromosomal syndrome (e.g., Fragile X Syndrome, Rett Syndrome), co-occurring neurological disorders (e.g., epilepsy) and/or previous history of hearing and vision problems, according to the parental report.

Children with DS were recruited from the Downside Up Charity Foundation, the Center for Early Help for Children with Down Syndrome (Moscow, Russia), or through acquaintances. All individuals had Trisomy 21, based on the parental report. None of the children with DS had ASD according to parental reports.

The participants' non-verbal IQ was measured with the Kaufman Assessment Battery for Children K-ABC II (A. S. Kaufman and N. L. Kaufman 2004). All TD children had normal—average or above average—non-verbal IQ (M = 111.2, SD = 15.6, range 86–146). The two clinical groups were matched for non-verbal IQ with no between-group differences, *non-verbal IQ,* $t(35.5) = 0.67$, $p = 0.50$: ASD group, M = 76.3, SD = 19.5, range 48–127; DS group, M = 62.4, SD = 9.6, range 53–94.

2.2 | Materials and Procedures

The materials included seven tests from the Russian Child Language Assessment Battery, RuCLAB (Arutiunian et al. 2022), including *Nonword Repetition, Object Naming, Action Naming, Noun Comprehension, Verb Comprehension, Sentence Repetition, Sentence Comprehension* tests. At the beginning of testing, we intended to administer the full RuCLAB battery (11 tests). However, most children in the DS group were unable to complete the *Sentence Production*, *Discourse Production*, and *Discourse Comprehension* tests, and they also had difficulty understanding the task of the *Phonological Discrimination* test. Therefore, these four tests were excluded, and analyses were conducted on the remaining seven. These seven tests assess expressive and receptive language skills at phonological, lexical and morphosyntactic levels (see Table 1 for details). All pictures and real words were selected from the Verbs and Nouns Stimuli Database for Russian, with name agreement for pictures above 85%. The audio stimuli were recorded by a professional female native speaker of Russian. The stimuli for all tests were presented with the AutoRAT application (see Arutiunian et al. 2022). All tests were programmed in Java SE8 and administered using a Samsung Galaxy Tab A SM-T515 model on the Android 9.0 platform with a screen size of 10.1″, 1920 × 1200 px (Table 1).

Each participant was tested in two sessions: during the first session, we assessed language abilities, and during the second, non-verbal IQ. All children were tested in a quiet room at the Center for Language and Brain, HSE University. At the beginning of each test, children were instructed and completed 2–3 practice trials that were excluded from the analysis. Participants could ask questions and get clarification during these practice trials, but they did not receive any feedback during the testing. The first session lasted about 40 to 60 min, including instruction and up to three breaks between the tests. The second session lasted from 30 to 40 min, including breaks between tests.

2.3 | Scoring

In the comprehension tests, accuracy was scored automatically in the AutoRAT application. The correct answers were coded as 1 whereas incorrect answers were coded as 0. In the production tests, participants' vocal responses were recorded in the application and analyzed and scored by the examiner offline.

For the *Nonword Repetition* test, accuracy was coded as 1 for correct repetition when participants pronounced all sounds of a pseudoword correctly and 0 for all other cases.

For the *Object* and *Action Naming* tests, accuracy was coded as 1 for correct naming and 0 for incorrect naming. We scored the response as correct when participants gave a name of the object or action (e.g., the word *bed* for a depicted *bed*) in any morphological form or produced a nomination from a predefined list of possible nominations, including diminutives. All other cases were scored as 0.

For the *Sentence Repetition* test, each correctly pronounced word in a sentence was scored as 1. The word order that deviated from the target word order was penalized with a −1 score. The resulting score for each sentence was divided by the number of words in the sentence. For example, when all words were repeated correctly in a three-word sentence, the participant received 3/3 = 1. When 1 word was missing in this sentence, the participant received 2/3 = 0.66.

2.4 | Statistical Analysis

All linear models used in the analysis were fitted in R (R Core Team 2019) using the *lme4* package (Bates et al. 2015), and the data were plotted with *ggplot2* (Wickham 2016). The structure of the particular models will be specified further in the Results section.

3 | Results

In this section, we first provide descriptive statistics across the seven language tests for all groups of children (TD, ASD, DS). We then report quantitative comparisons between TD children and each of the clinical groups, with all groups analysed within a single model for each test. Next, we present comparisons between the ASD and DS groups and examine how psycholinguistic variables in each test are associated with children's scores. The variables were selected based on a previous study of Russian-speaking children with ASD (Arutiunian et al. 2021, 2022). Finally, for the ASD and DS groups, we report analyses of the associations between non-verbal IQ and age with test scores, conducted within a single model for each test.

TABLE 1 | Language tests and materials.

Test (linguistic level)	Task	Controlled variables	Stimulus
1. Nonword repetition (phonology)	Listen to the nonwords and repeat them ($n = 24$)	Following phonotactic rules of Russian Length (1, 2, and 3 syllables long) Number of articulatory switches (0, 1, 2, and 3)	*nus* (1-syllable long, 0 articulatory switches) *spikva* (2-syllable long, 3 articulatory switches)
2. Object naming (vocabulary)	Name objects depicted in the picture ($n = 24$)	*Pictures*: Subjective visual complexity Familiarity Imageability *Words*: Age of acquisition Frequency (low, medium, high)	Objects: *butylka (bottle)* (early age of acquisition, high frequency) *edinorog (unicorn)* (late age of acquisition, low frequency) Actions: *zvonit' (to ring)* (late age of acquisition, high frequency) *risovat' (to draw)* (early age of acquisition, medium frequency)
3. Action naming (vocabulary)	Name actions depicted in the picture ($n = 24$)		
4. Noun comprehension (vocabulary)	Listen to the object words and match them with one out of four pictures ($n = 24$)	*Pictures*: Subjective visual complexity Familiarity Imageability *Words*: Age of acquisition Frequency (low, medium, high) Length	Nouns: *yula (whirligig)* (early age of acquisition, low frequency) *shchit (shield)* (late age of acquisition, medium frequency) Verbs: *spat' (to sleep)* (early age of acquisition, high frequency) *gresti (to row)* (late age of acquisition, low frequency)
5. Verb comprehension (vocabulary)	Listen to the action words and match them with one out of four pictures ($n = 24$)		
6. Sentence repetition (morphosyntax)	Listen to the sentences and repeat them back ($n = 12$)	Sentence length (3 or 6 content words) Frequency of word lemmas (low, high)	*Mal'chiki smotryat fil'm* ('The boys are watching a movie') (short, high-frequency condition) *Kloun lovko ob"ekhal golodnyh tigrov na velosipede* ('The clown deftly circled the hungry tigers on a bicycle') (long, low-frequency condition)
7. Sentence comprehension (morphosyntax)	Listen to the sentences and match them with one out of two pictures ($n = 24$)	Number of verb arguments (1, 2, and 3) Type of third argument (Instrumental or Prepositional) Word order (canonical SVO or non-canonical OVS) Construction type (simple constructions, subject and object relative clauses, reflexive constructions, prepositional constructions)	*Gde vnuchka kormit babushku?* Where granddaughter.NOM feed.PRS.3 grandmother.ACC ('Where is the granddaughter feed the grandmother?') (2 arguments, canonical SVO, simple) *Gde tyotya, kotoruyu celuet dyadya?* Where aunt.ACC that kiss.PRS.3 uncle.NOM ('Where is the aunt that uncle kisses?) (2 arguments, non-canonical OVS, object relative clauses) *Gde babushka nakryvaet sharf shapkoj?* Where grandmother.NOM cover.PRS.3 scarf.ACC hat.INSTR ('Where is grandmother cover the scarf with a hat?') (3 arguments, Instrumental, canonical SVO)

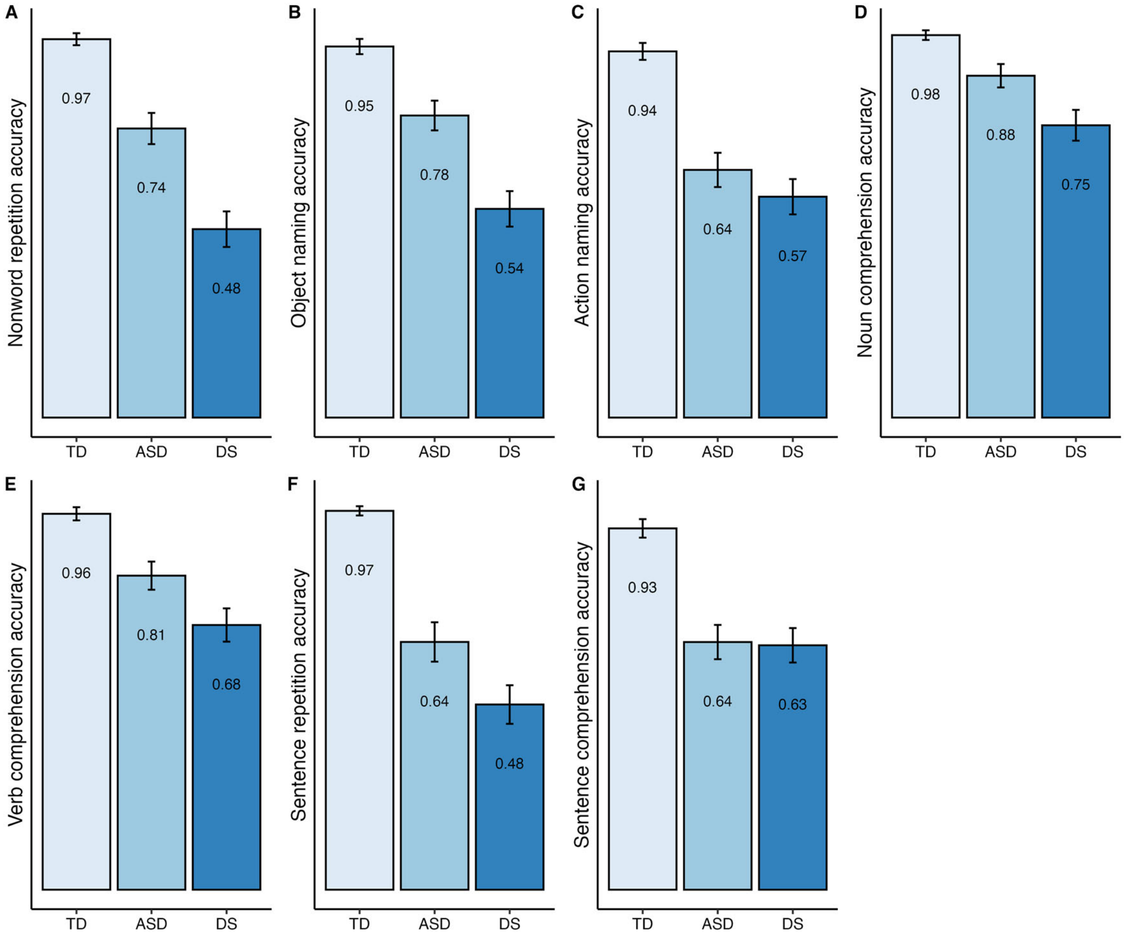

FIGURE 1 | Descriptive statistics across TD, ASD, and DS groups. (A) Nonword repetition; (B) object naming; (C) action naming; (D) noun comprehension; (E) verb comprehension; (F) Sentence repetition; (G) sentence comprehension. Error bars represent 95% confidence intervals. ASD = autism spectrum disorder, DS = Down syndrome, TD = typically developing controls.

3.1 | Descriptive Statistics

All TD children were able to complete the full language assessment. By contrast, not all children from the ASD and DS groups completed all tests: four children with ASD and three children with DS did not complete at least one test, including *Nonword Repetition* (DS = 1), *Object Naming* (ASD = 1, DS = 2), *Action Naming* (ASD = 2, DS = 3), *Verb comprehension* (ASD = 1), *Sentence Repetition* (ASD = 4, DS = 3), and *Sentence Comprehension* (ASD = 2). Figure 1 shows descriptive statistics for accuracy across all groups of children.

3.2 | Group Comparison of Language Skills

In order to compare the response accuracy of both ASD and DS groups with the TD controls, for each language test we fitted generalized linear mixed-effects models or linear mixed-effects models with accuracy as the dependent variable, the main effect of group (TD group coded as 0) as a fixed effect, and participants and items as random intercepts. The model for each test was as follows: (g)lmer(Accuracy ∼ Group + (1 | ID) + (1 | Item)). We applied a Bonferroni correction, so that the predictors are significant at the $\alpha = 0.007$ level (total number of fitted models with the main effect of group = 7) but reported uncorrected p values.

As expected, comparisons between TD and ASD, as well as TD and DS groups, revealed significant differences in accuracy for each language test in both groups of children with neurodevelopmental disorders when compared to TD controls, with the evidence of lower language skills in clinical groups (see Table 2 and Figure 2).

3.3 | Comparisons of Language Profiles in ASD and DS

To provide a comparison in language profiles between children with ASD and DS, we fitted six models with nested effects assessing both between-group comparisons in accuracy (ASD vs. DS) as well as the influence of different psycholinguistic variables on accuracy in each group (see details further). We applied a Bonferroni correction, so that the predictors are significant at the $\alpha = 0.008$ level (total number of fitted models with the main effect of group = 6) but reported uncorrected p values. The outputs of the models are reported in Table 3.

Nonword Repetition. A generalized linear mixed-effects model was fitted with the accuracy as the dependent variable and included the main effect of group (DS coded as 0) and the effect of stimulus length nested within the ASD and DS groups as

TABLE 2 | Group comparisons in accuracy for each language test.

	Accuracy							
	TD versus ASD				TD versus DS			
Test	***β***	**SE**	***z/t***	***p***	***β***	**SE**	***z/t***	***p***
Nonword repetition	−2.83	0.50	−5.69	< 0.001*	−4.39	0.01	−8.70	< 0.001*
Object naming	−2.61	0.80	−3.28	0.001*	−4.69	0.81	−5.79	< 0.001*
Action naming	−3.37	0.76	−4.44	< 0.001*	−3.83	0.76	−5.03	< 0.001*
Noun comprehension	−1.98	0.55	−3.60	< 0.001*	−3.33	0.54	−6.16	< 0.001*
Verb comprehension	−2.02	0.52	−3.88	< 0.001*	−3.07	0.52	−5.95	< 0.001*
Sentence repetition	−0.33	0.08	−4.05	< 0.001*	−0.50	0.08	−5.98	< 0.001*
Sentence comprehension	−2.29	0.38	−6.03	< 0.001*	−2.35	0.38	−6.25	< 0.001*

Note: Predictors significant at the $\alpha = 0.05$ significance level are highlighted in bold. Predictors that retained their significance following the Bonferroni correction for the total number of models (that is, significant at the $\alpha = 0.007$ level) are also labelled with * (reported p values are uncorrected).
Abbreviations: ASD = autism spectrum disorder, DS = Down syndrome, TD = typically developing controls.

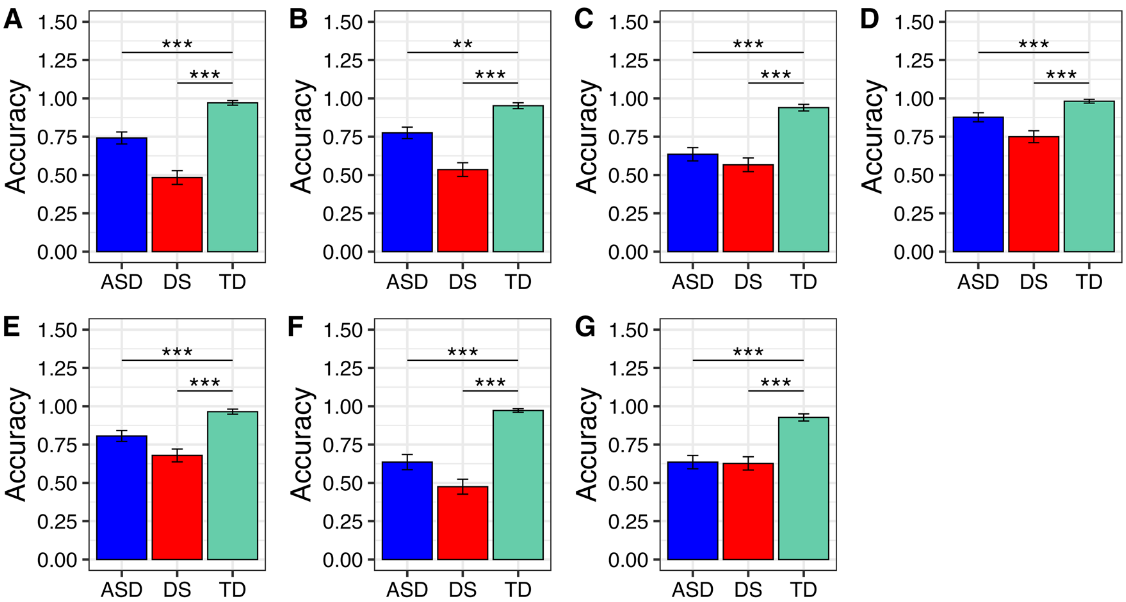

FIGURE 2 | Group comparisons in each language test. (A) Nonword repetition; (B) object naming; (C) action naming; (D) noun comprehension; (E) verb comprehension; (F) sentence repetition; (G) sentence comprehension. The significance is labelled with $*p < 0.05$, $**p < 0.01$, $***p < 0.001$. ASD = autism spectrum disorder, DS = Down syndrome, TD = typically developing controls.

fixed effects and participants and items as random intercepts. The results showed a significant main effect of group, so that the ASD group had higher accuracy, $\beta = 0.79$, SE = 0.21, $z = 3.71$, $p < 0.001$ (see Figure 3). The stimulus length did not influence accuracy in any group of children.

Object versus *Action Naming*. To examine the influence of word class (nouns vs. verbs) on accuracy in word production in both groups, we merged the data of the two tests and fitted a generalized linear mixed-effects model with accuracy as the dependent variable, the main effect of group (DS coded as 0) and the effect of word class nested within the ASD and DS groups as fixed effects, and participants and items as random intercepts. In the ASD group, we found that objects have been named with higher accuracy in comparison to actions, $\beta = 1.10$, SE = 0.19, $z = 5.94$, $p < 0.001$, but there was no difference between object and action naming in the DS group (see Figure 3).

Noun versus *Verb Comprehension*. The model with the same structure as for production has been fitted for word comprehension. In both groups of children, we revealed a significant effect of word class, so that nouns were comprehended with higher accuracy than verbs: ASD group, $\beta = 0.75$, SE = 0.21, $z = 3.57$, $p < 0.001$; DS group, $\beta = 0.44$, SE = 0.16, $z = 2.74$, $p = 0.006$ (see Figure 3).

Sentence Repetition. We fitted a linear mixed-effects model with accuracy as the dependent variable, the main effect of group (DS coded as 0), as well as the effects of frequency (high vs. low) and length (short vs. long) nested within the ASD and DS groups as

TABLE 3 | Comparisons of language profiles in children with autism spectrum disorder (ASD) and Down syndrome (DS): Output of the models.

	Nonword repetition					Object vs. action naming					Noun vs. verb comprehension			
Predictors	β	**SE**	z	p	***Predictors***	β	**SE**	z	p	***Predictors***	β	**SE**	z	p
(Intercept)	0.62	0.27	2.32	0.020	(Intercept)	0.50	0.38	1.30	0.194	(Intercept)	1.45	0.25	5.77	<0.001*
ASD group	0.79	0.21	3.71	<0.001*	ASD group	0.27	0.35	0.79	0.431	ASD group	0.52	0.22	2.39	0.017
ASD group / Length	−0.19	0.25	−0.75	0.453	ASD group / Object	1.10	0.19	5.94	<0.001*	ASD group, Nouns	0.75	0.21	3.57	<0.001*
DS group / Length	−0.37	0.24	−1.57	0.117	DS group / Object	−0.21	0.17	−1.28	0.200	DS group, Nouns	0.44	0.16	2.74	0.006*
Random Effects					**Random Effects**					**Random Effects**				
σ^2	3.29				σ^2	3.29				σ^2	3.29			
$\tau_{00\ ID}$	1.52				$\tau_{00\ ID}$	4.42				$\tau_{00\ ID}$	1.53			
$\tau_{00\ Item}$	0.61				$\tau_{00\ Item}$	0.61				$\tau_{00\ Item}$	0.38			
ICC	0.39				ICC	0.60				ICC	0.37			
N_{ID}	40				N_{ID}	40				N_{ID}	40			
N_{Item}	24				N_{Item}	24				N_{Item}	24			
Observations	960				Observations	1920				Observations	1919			
Marginal R^2 / Conditional R^2	0.113 / 0.461				Marginal R^2 / Conditional R^2	0.059 / 0.628				Marginal R^2 / Conditional R^2	0.080 / 0.418			

(Continues)

TABLE 3 | (Continued)

	Sentence repetition					Sentence comprehension					Sentence comprehension			
Predictors	***β***	**SE**	***t***	***p***	***Predictors***	***β***	**SE**	***z***	***p***	***Predictors***	***β***	**SE**	***z***	***p***
(Intercept)	0.48	0.06	8.59	<0.001	(Intercept)	−0.04	0.23	−0.19	0.850	(Intercept)	0.37	0.24	1.56	0.118
ASD group	0.11	0.05	2.13	0.033	ASD group	−0.29	0.23	−1.26	0.209	ASD group	−0.01	0.23	−0.03	0.980
ASD group / Length, short	0.19	0.03	5.73	<0.001*	ASD group, Indirect	0.77	0.35	2.20	0.028	ASD group, SVO	0.95	0.32	2.99	0.003*
DS group / Length, short	0.33	0.03	9.60	<0.001*	DS group, Indirect	0.39	0.33	1.16	0.245	DS group, SVO	0.43	0.29	1.51	0.132
ASD group / Frequency, low	−0.11	0.03	−3.25	0.001*	ASD group, Prepositional	0.65	0.35	1.87	0.061					
DS group / Frequency, low	−0.12	0.03	−3.52	<0.001*	DS group, Prepositional	−0.17	0.33	−0.50	0.617					
Random Effects					**Random Effects**					**Random Effects**				
σ^2	0.03				σ^2	3.29				σ^2	3.29			
$\tau_{00\ \mathrm{ID}}$	0.10				$\tau_{00\ \mathrm{ID}}$	0.41				$\tau_{00\ \mathrm{ID}}$	1.31			
$\tau_{00\ \mathrm{Item}}$	0.00				$\tau_{00\ \mathrm{Item}}$	0.00				$\tau_{00\ \mathrm{Item}}$	0.04			
ICC	0.76				N_{ID}	40				ICC	0.29			
N_{ID}	40				N_{Item}	8				N_{ID}	40			
N_{Item}	12				Observations	320				N_{Item}	14			
Observations	480				Marginal R^2 / Conditional R^2	0.044 / NA				Observations	560			
Marginal R^2 / Conditional R^2	0.172 / 0.800									Marginal R^2 / Conditional R^2	0.031 / 0.313			

Note: Predictors significant at $\alpha = 0.05$ significance level are highlighted in bold. Predictors that retained their significance following the Bonferroni correction for the total number of models (that is, significant at the $\alpha = 0.008$ level) are also labelled with * (reported *p* values are uncorrected).

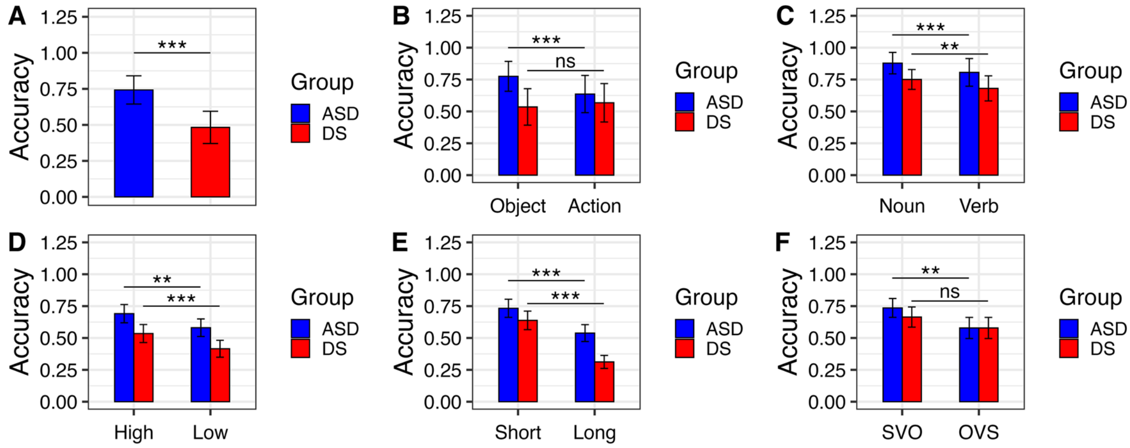

FIGURE 3 | Language profiles of children with autism spectrum disorder (ASD) and Down syndrome (DS). (A) between-group difference in accuracy on nonword repetition test. (B) Object versus action naming; (C) noun versus verb comprehension; (D) sentence repetition (the influence of word frequency on the accuracy: high—sentences consisting of high frequency words, low—sentences consisting of low frequency words); (E) sentence repetition (the influence of sentence length on the accuracy: short—short sentences, long—long sentences); (F) sentence comprehension (the influence of word order on the accuracy: SVO—canonical subject-verb-object, OVS—non-canonical object-verb-subject). The significance is labelled with $*p < 0.05$, $**p < 0.01$, $***p < 0.001$, ns = non-significant (reported p values are uncorrected).

fixed effects, and participants and items as random intercepts. We revealed that both children with ASD and children with DS repeated short sentences and sentences consisting of high-frequency words better than long sentences and sentences consisting of low-frequency words: ASD group, *frequency,* $\beta = -0.11$, SE = 0.03, $t = -3.25$, $p = 0.001$, *length,* $\beta = 0.19$, SE = 0.03, $t = 5.73$, $p < 0.001$; DS group, *frequency,* $\beta = -0.12$, SE = 0.03, $t = -3.52$, $p < 0.001$, *length,* $\beta = 0.33$, SE = 0.03, $t = 9.60$, $p < 0.001$ (see Figure 3).

Sentence Comprehension. We fitted two generalized linear mixed-effects models with accuracy as the dependent variable and (1) with the main effect of group (DS coded as 0) and the effects of the type of the third argument (instrumental, prepositional) and the arguments' order (direct, indirect) nested within the ASD and DS groups as fixed effects; (2) with the main effect of group (DS coded as 0) and the effect of word order (canonical SVO, noncanonical OVS) nested within the ASD and DS groups as fixed effects. In both models, participants and items were included as random intercepts. The results showed that children with ASD comprehended sentences with canonical SVO word order more accurately than sentences with noncanonical OVS word order, $\beta = 0.95$, SE = 0.32, $z = 2.99$, $p = 0.003$; in the DS group, we did not find that effect (see Figure 3). All other effects were non-significant.

To summarize, the comparison of ASD and DS groups in language tests as well as the analysis of the influence of psycholinguistic variables on accuracy within each of the groups demonstrated that (1) *Nonword Repetition* was the only test in which children with ASD showed higher accuracy compared to children with DS; and (2) even though the pattern of the influence of some psycholinguistic variables on the accuracy was similar between the groups (e.g. better noun than verb comprehension; more accurate repetition of sentences with short and high-frequency words than those with long and long-frequency words), several features were distinct in children with ASD and DS (e.g. better object than action naming only in children with ASD; better comprehension of sentences with SVO than with OVS word order only in children with ASD).

3.4 | The Influence of Non-Verbal IQ and Age on Language Skills in Both Clinical Groups

To assess the relationship between the language skills and non-language factors (non-verbal IQ and age) in the ASD and DS groups, we fitted seven linear models (one model for each language test) with accuracy as a dependent variable. Each model included the group and the interactions of the group with non-verbal IQ and with age, allowing the effects of these predictors to differ between the ASD and DS groups. The model for each test was as follows: lm(Accuracy ∼ Group/non-verbal IQ + Group/age). Bonferroni correction was applied, so that the predictors are significant at the $\alpha = 0.007$ level (total number of fitted models = 7); reported p values are uncorrected.

The results showed that in the DS group, there were no significant relationships between the accuracy in language tests and neither non-verbal IQ nor age (Table 4). By contrast, in the ASD group, we found a significant effect of non-verbal IQ in three out of seven tests, revealing that better language skills were associated with higher non-verbal IQ (see Table 4, Figure 4): *Verb Comprehension,* $\beta = 0.01$, SE = 0.00, $t = 4.16$, $p < 0.001$; *Sentence Repetition,* $\beta = 0.02$, SE = 0.00, $t = 4.34$, $p < 0.001$; and *Sentence Comprehension,* $\beta = 0.02$, SE = 0.00, $t = 4.88$, $p < 0.001$.

4 | Discussion

In this study, we provided a direct comparison of language skills in non-verbal IQ-matched children with ASD and DS at different linguistic levels. Using a subset of tests from the RuCLAB, we described language profiles in production and comprehension across three linguistic levels—phonological, lexical, and morphosyntactic. We also explored the influence of non-verbal IQ and age on language skills in children with ASD and DS. The key conclusion was that the language profiles of children with ASD differed from those of children with DS regardless of non-verbal IQ.

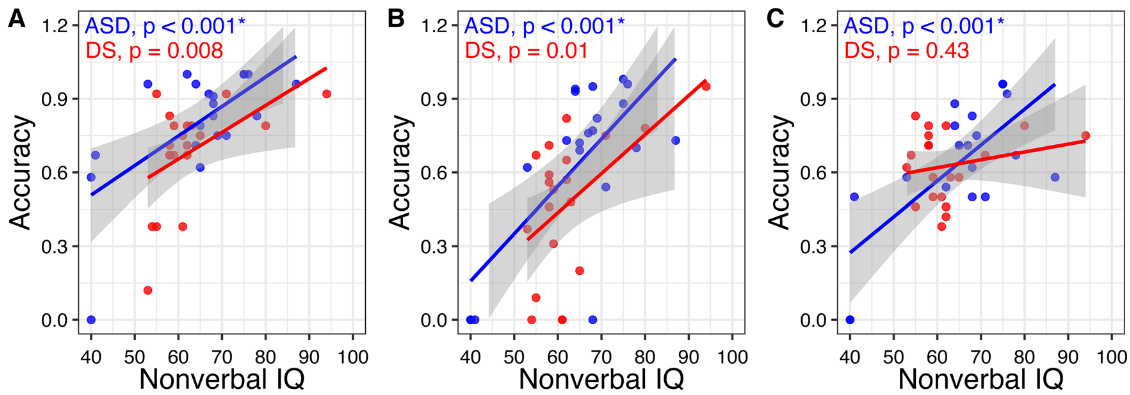

FIGURE 4 | The influence of non-language factors on language skills of children with autism spectrum disorder (ASD) and Down syndrome (DS): (A) Verb comprehension, (B) Sentence repetition, (C) Sentence comprehension. The significance is set up at the $\alpha = 0.007$ level, following the Bonferroni correction, and labelled with * (reported *p* values are uncorrected).

The overall comparison of performance across all language tests revealed that both children with ASD and children with DS had significantly lower accuracy on tasks assessing language production and comprehension compared to their TD peers. This finding indicates that both clinical groups experience language difficulties at the levels of phonology, vocabulary, and morphosyntax. A direct comparison of clinical groups (ASD vs. DS) in accuracy for each language test showed a significant difference only for the test assessing phonological skills, suggesting that children with DS had lower skills, which is partially consistent with the findings of Koizumi et al. (2020), Roberts, Price, Barnes, et al. (2007), and Udhnani et al. (2020) and contradicts the conclusions of Martin et al. (2018). In general, the nonword repetition task is considered as a measure of verbal working memory/phonological short-term memory (Bishop et al. 1996), and this supports the evidence that language difficulties in children with DS can be explained by the specific impairment in the phonological loop (Buckley and Le Prèvost 2002; Jarrold et al. 1999).

In both clinical groups, expressive language scores, aggregated across *Nonword Repetition, Object Naming, Action Naming*, and *Sentence Repetition* tests, were lower than receptive language scores, aggregated across *Noun Comprehension, Verb Comprehension*, and *Sentence Comprehension* tests. The relative difference between expressive and receptive language domains was 8% for the ASD group and 18% for the DS group. These results align with previous findings that expressive language is more impaired than receptive in children with ASD (Arutiunian et al. 2021; Luyster et al. 2008) and children with DS (Abbeduto et al. 2007; Næss et al. 2011).

The detailed analysis of psycholinguistic variables revealed both similarities and differences in language profiles of children with ASD and DS. In the *Sentence Repetition* task, both clinical groups found it more challenging to repeat longer sentences compared to shorter ones, as well as sentences containing low-frequency words compared to high-frequency words. This is in line with the previous studies showing that syntactic complexity influences language performance in different neurodevelopmental disorders, including ASD, DS, and developmental language disorder (Antonijevic-Elliott et al. 2019; Abbeduto et al. 2007; Arutiunian et al. 2022). This deficit can also be related to impairments in phonological short-term memory (Buckley and Le Prévost 2002; Jarrold et al. 1999). In word comprehension tasks, children with ASD and DS also showed similar patterns, so that both groups comprehended nouns with higher accuracy in comparison to verbs. This is consistent with the previous findings on lexical development in children with ASD and DS (Arutiunian et al. 2022; Chapman 2003; Swensen et al. 2007; Witecy and Penke 2017) as well as in TD children (D'Odorico and Fasolo 2007). However, despite the similarities in some linguistic patterns between both clinical groups, we also revealed that children with DS appeared to be less sensitive to the manipulation of linguistic variables compared to children with ASD. Specifically, in word naming tasks, we found that only children with ASD, but not those with DS, name objects more accurately than actions. Furthermore, only children with ASD benefit from canonical SVO word order compared to non-canonical OVS word order in the *Sentence Comprehension* task, whereas for children with DS, the word order manipulation didn't show an effect. As suggested by Arutiunian et al. (2022), who described language profiles in a large group of Russian-speaking children with ASD, some children with ASD, including those studied in this paper, may exhibit delayed language development profiles similar to those observed in younger TD children. In contrast, the language profiles of children with DS appear to differ, reflecting impaired language performance that is less comparable to that of younger children.

In both clinical groups, we found no association between the age of participants and their performance on any of the seven language tests, which corresponds to most of the previous studies (e.g., Arutiunian et al. 2022; Figueroa and Darbra 2025). However, we revealed a difference between the two groups in the effect of non-verbal IQ. In children with ASD, higher IQ scores were associated with better performance in *Verb Comprehension*, *Sentence Comprehension*, and *Sentence Repetition* tests. In children with DS, non-verbal IQ was not related to language performance. The majority of the previous studies on children with ASD have shown that non-verbal IQ is one of the major predictors of language skills at different linguistic levels in both production and comprehension (e.g., Arutiunian et al. 2022; Kjelgaard and Tager-Flusberg 2001; Nevill et al. 2019). The absence of this effect in children with DS, together with their lower sensitivity to different linguistic variables compared to children with ASD, highlighted the different 'nature' of language impairment in children with DS.

TABLE 4 | The association between non-language factors (nonverbal IQ and age) and language skills of children with autism spectrum disorder (ASD) and Down syndrome (DS).

Test	ASD group								DS group							
	Age				Nonverbal IQ				Age				Nonverbal IQ			
	β	SE	*t*	*p*	*β*	SE	*t*	*p*	*β*	SE	*t*	*p*	*β*	SE	*t*	*p*
Nonword repetition	0.04	0.05	0.81	0.42	0.00	0.00	1.80	0.08	0.03	0.04	0.88	0.39	0.00	0.00	1.97	0.06
Object naming	−0.08	0.05	−1.54	0.13	0.01	0.00	2.79	**0.008**	0.05	0.04	1.23	0.23	0.01	0.00	2.00	**0.05**
Action naming	−0.07	0.06	−1.11	0.27	0.01	0.00	2.63	**0.01**	0.04	0.05	0.75	0.46	0.01	0.01	2.14	**0.04**
Noun comprehension	−0.02	0.03	−0.58	0.56	0.00	0.00	1.98	**0.05**	0.05	0.03	1.84	0.07	0.00	0.00	2.03	**0.05**
Verb comprehension	−0.06	0.04	−1.66	0.11	0.01	0.00	4.16	**< 0.001***	0.08	0.03	2.76	**0.009**	0.01	0.00	2.80	**0.008**
Sentence repetition	−0.08	0.05	−1.53	0.13	0.02	0.00	4.34	**< 0.001***	0.06	0.04	1.31	0.20	0.02	0.00	2.71	**0.01**
Sentence comprehension	−0.04	0.04	−1.19	0.24	0.02	0.00	4.88	**< 0.001***	0.02	0.03	0.87	0.39	0.00	0.00	0.80	0.43

Note: Predictors significant at $\alpha = 0.05$ significance level are highlighted in bold. Predictors that retained their significance following the Bonferroni correction for the total number of models (that is, significant at the $\alpha = 0.007$ level) are also labelled with * (reported *p* values are uncorrected).

Our findings suggest that the language profiles of children with ASD mostly corresponded to the early stages of typical language development and were related to the overall 'mental' age, whereas children with DS mostly showed impaired language skills that were not related to developmental level.

To summarize, our findings provide new insights into the language profiles of IQ-matched children with ASD and children with DS. We found that the two groups exhibited distinct language profiles. Specifically, school-aged children with ASD demonstrated similarities to younger TD children: they were sensitive to word order manipulation in sentences and to word class distinctions in word comprehension and production tasks. Additionally, higher IQ scores in children with ASD were associated with better performance in complex language tests. In contrast, children with DS had lower scores in the phonological assessment test and exhibited sensitivity to only certain linguistic manipulations, such as word class in word comprehension tests and sentence length and word frequency in the *Sentence Repetition* test, and their language skills were not related to overall developmental level.

4.1 | Clinical Implications

This study demonstrated differences in the language profiles of children with ASD and children with DS, independent of non-verbal IQ, and identified specific impairments related to linguistic levels and structural language characteristics. These findings contribute to speech and language therapy strategies by highlighting specific linguistic deficits that should be targeted in the intervention. We showed that the language difficulties in children with ASD were mostly 'developmental in nature' and the profiles were associated with the earlier stages of typical language development. Additional evidence supporting this finding was the relationship between language skills and overall developmental level in autistic children. By contrast, children with DS showed another pattern with more impaired language profiles that were not related to non-verbal cognition and did not correspond much to earlier stages of language development in comparison to the ASD group. The difference between 'language delay' and 'language impairment,' as well as a detailed understanding of an individual child's language profile at different linguistic levels, could help speech-language therapists select the most appropriate targets for therapy.

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Ethics Statement

This study was approved by the HSE University Committee on Interuniversity Surveys and Ethical Assessment of Empirical Research and the ethics committee of Moscow State University of Psychology and

Education and was conducted in accordance with the Declaration of Helsinki. A parent of each child provided a written informed consent.

Consent

A parent of each child provided a written informed consent.

Conflicts of Interest

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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