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Lexical Knowledge in School-Aged Children with High-Functioning Autism Spectrum Disorder: Associations with Other Linguistic Skills

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Abstract: Background: This quasi-experimental comparative group study examined vocabulary knowledge and its associations with other language skills in Greek-speaking children with high-functioning Autism Spectrum Disorder and mild language impairment (HF-ASDLI) and typically developing (TD) peers. Methods: 25 children aged 7–10 years old participated in each group. Groups were matched in age, gender, and non-verbal IQ. Naming and word definition tasks were used to evaluate vocabulary knowledge in both groups. Results: Groups did not differ in the naming task; however, children with HF-ASDLI scored lower in the definition task. Both vocabulary tasks positively correlated with morpho-syntactic and overall language ability in both groups, although a significant positive correlation was detected between vocabulary knowledge and informational competence exclusively in the group with HF-ASDLI. Conclusions: Being in the HF-ASDLI group and having narrative ability significantly predicted participants' performance in the definitions task, indicating that language impairment better explains vocabulary difficulties. These results agree with findings from the English language.

Keywords: ASD; lexical development; vocabulary depth; vocabulary development; vocabulary size

Citation: Zarokanellou, Vasiliki, Alexandra Prentza, Dionysios Tafiadis, Gerasimos Kolaitis, and Katerina Papanikolaou. 2024. Lexical Knowledge in School-Aged Children with High-Functioning Autism Spectrum Disorder: Associations with Other Linguistic Skills. *Languages* 9: 31. https://doi.org/10.3390/languages9010031

Academic Editor: Jon Clenton

Received: 30 September 2023
Revised: 21 December 2023
Accepted: 10 January 2024
Published: 18 January 2024

1. Introduction

Lexical knowledge is a multidimensional construct typically examined by vocabulary size and depth (Schmitt 2010, 2014). Vocabulary size (breadth) refers to the number of known words in the mental lexicon, while vocabulary depth refers to the stability and accuracy with which a given word is represented in the mental lexicon (McGregor et al. 2012). Vocabulary size or breadth is usually assessed by calculating accurate or inaccurate naming responses, while vocabulary depth is often evaluated by defining words, producing synonyms and antonyms, and making word associations. No vocabulary task can fully isolate breadth from depth, but there is some evidence suggesting that breadth and depth of vocabulary knowledge are strongly correlated with vocabulary meaning (Schmitt 2014).

Psycholinguistic features of words, such as word class, frequency, concreteness/imageability, and polysemy influence word learning in TD children (Schmitt 2010). Word class refers to whether a word is a content or a function word. Content words include nouns, verbs, adjectives, and adverbs and carry semantic meaning, while function words include words such as conjunctions, prepositions, determiners, modals, etc., which have grammatical functions. Concreteness/imageability refers to the degree to which a word

can be experienced by the senses or the easiness with which it can be imagined. Words of high imageability tend to be concrete words (Schmitt 2010). Polysemy refers to whether a word has more than one meaning, such as the word "paper", which can refer to both the material and a scientific publication (Klein and Murphy 2001). TD children tend to more easily acquire high-frequency content words that are concrete, such as nouns and verbs, as well as functional words, such as pronouns, determiners, prepositions, etc., that they use in their everyday interaction and activities (Clark 2001; Hoff and Naigles 2002). Additionally, TD children first acquire the most frequent meaning of a polysemous word and subsequently, acquire the rest of its meanings (Schmitt 2010).

Moreover, an interrelation has been identified between early vocabulary acquisition and syntactic development, since the knowledge of morphosyntax helps children to understand new word meanings and deepen their word knowledge (Arunachalam and Luyster 2016; McGregor et al. 2012; Weismer et al. 2011). TD children, very early in life, at about 1;6 years of age, use the syntactic frames within which verbs are presented to understand their meaning, a process which is referred to as "syntactic bootstrapping" (Arunachalam and Luyster 2016). Additionally, as children acquire new vocabulary, they also learn the syntactic structures in which these words correctly and appropriately emerge (McGregor et al. 2012). The relative importance of lexical versus syntactic development changes with age: while the acquisition of morphosyntax is complete before school age, new words are acquired throughout life. However, lexical–syntactic development continues well into the school years and can be observed in older children when they try to understand complex syntactic structures or new words with non-observable referents, such as abstract nouns (McGregor et al. 2012).

1.1. Size and Depth of Vocabulary Knowledge in Children with High-Functioning Autism Spectrum Disorder

Several studies have examined lexical development in high-functioning individuals with ASD (hence HF-ASD), since it is characterized by a unique developmental trajectory that is often associated with late-onset of lexical acquisition and/or advanced word use, pedantic and/or perseverative speech, and deficits in word knowledge (Arunachalam and Luyster 2016; McGregor et al. 2012; Perkins et al. 2006; Walenski et al. 2006, 2008). These studies suggest that individuals with HF-ASD process the phonological and semantic forms of new words as successfully as TD peers, thus acquiring equal or even superior naming abilities, but do not show an asymmetry between receptive and productive language skills, which is the typical pattern observed in their TD peers (Arunachalam and Luyster 2016; Haebig et al. 2015, 2017; Lucas et al. 2017; Norbury et al. 2010; Walenski et al. 2008).

Moreover, several studies propose that certain classes of words, such as temporal, spatial, and deictic terms, mental state terms, and emotion words, as well as passive structures, are underrepresented in the mental lexicon of individuals with HF-ASD (Durrleman et al. 2017; Félix et al. 2022; Moseley et al. 2013, 2015; Perkins et al. 2006; Tek et al. 2014). Furthermore, a recent study on Cypriot-Greek bidialectal children reported that children with HF-ASDLI show significantly more deficits than their TD peers in naming compound words (Kambanaros et al. 2018). Although generally, but not universally, children with ASD and broader language impairments (LIs) also present impaired lexical skills, a recent review focusing on lexical semantic knowledge in children with ASD reported significant variability in the outcomes of vocabulary tasks, thus not identifying a single crucial factor, such as the age, IQ scores, task type, or linguistic level of the ASD participants in other language domains, which could effectively explain the differences in lexical knowledge performance (Sukenik and Tuller 2023). According to the review, the vocabulary task type was a variable that could possibly explain the heterogeneity between the results of relevant research, since most vocabulary tasks tap into a specific ability that may or may not be related to other lexical or semantic features. However, as Sukenik and Tuller (2023) point out, this was not confirmed by the analyses of previous research, as most included studies tested only one vocabulary variable. On par with the above, many researchers suggest

that children with HF-ASD have underdeveloped word knowledge and often fail to access the subordinate meanings of polysemous words or experience difficulties in the efficient processing of context; thus, they frequently underperform in word definition or association tasks, providing more superficial and immature definitions in word meanings, and more unrelated answers compared to their TD peers (Félix et al. 2022; Kambanaros et al. 2018; Lucas et al. 2017; McGregor et al. 2012; Norbury 2005; Norbury et al. 2010). Conclusively, individuals with HF-ASD may exhibit specific expressive and receptive vocabulary deficits, which are not always easily detectable through standardized naming tests.

1.2. Associations between Lexical Knowledge and Other Language Skills in Children with High Functioning Autism Spectrum Disorder

In an attempt to explain the aforementioned disparities in lexical development, some researchers have suggested that certain psycholinguistic features of word stimuli, such as content, frequency, imageability, concreteness, and word class, play an important role in the understanding and generalization of word meaning, since the mastery of certain kinds of words such as deictic terms, mental state terms, and emotion words rely on complex social cognitive skills (such as perspective-taking and Theory of Mind), in which children with HF-ASD lag behind (Arunachalam and Luyster 2016).

Other researchers have investigated how syntactic bootstrapping (morpho-syntactic development), or overall language ability affects vocabulary development in this specific population and suggest that vocabulary deficits stem from co-occurring LIs and that they are not a unique characteristic of ASD disorder (Lucas et al. 2017; McGregor et al. 2012; Norbury 2005; Tek et al. 2014; Weismer et al. 2011). Indeed, Weismer et al. (2011) and Tek et al. (2014) examined vocabulary size and grammatical development in toddlers with ASD aged 22 to 37 months. Both studies showed that ASD toddlers did not differ in vocabulary size or in the word categories they used, when compared to older vocabulary-matched late talkers or younger language-matched TD toddlers. These results led Weismer et al. (2011) to propose that ASD toddlers demonstrate qualitatively similar vocabulary patterns of word combinations and grammatical complexity scores to those of older late-talker toddlers. Additionally, the findings of Tek et al. (2014) revealed different growth rates of expressive vocabulary and morpho-syntax in ASD toddlers with and without language delay. The above research emphasizes that lexical development is not qualitatively different in HF-ASD populations and strongly relates to overall language development. Additionally, Eigsti et al. (2007), who assessed vocabulary size and syntactic development in preschool children with HF-ASD (3–6 years old), found that children with ASD did not differ in type/token ratios when compared to younger TD children and were matched in cognitive abilities and receptive vocabulary. However, the ASD group did present significant syntactic delays and produced more nonsense words in play sessions than the TD group. Moreover, these researchers proposed that children with ASD were less likely than the TD group to refer to things (i.e., items, events, or people) not physically or temporally present. Also, Walenski et al. (2008), in their study, reported enhanced naming performance for children with HF-ASD aged 8–14 years old, in comparison with two age-matched, full-scale IQ-matched, and education-matched TD male or female control groups. The researchers suggested that naming skills may be an enhanced aspect of the language profile of children with ASD, regardless of the deficits they may present in other language skills. On the other hand, Kambanaros et al. (2018), who examined naming and production of definitions in compositional noun–noun compound words in four Cypriot-Greek bidialectal children with HF-ASDLI aged 6.3 to 8.9 years, suggested that the participants with ASDLI had significantly lower performance in both tasks compared to their TD peers. Finally, the scarce research available (Lucas et al. 2017; McGregor et al. 2012; Norbury 2005) that compared vocabulary size and/or depth among individuals with HF-ASDLI, individuals with HF-ASD without LIs, and TD peers aged 8 to 17 years old, revealed that individuals with HF-ASD without LIs do not differ in vocabulary size or depth in comparison to their TD peers. McGregor et al. (2012) also reported a moderate positive correlation (r = 0.54)

between syntax and vocabulary depth for children with HF-ASD and a high positive correlation(r = 0.71) between syntax and vocabulary depth for age-matched peers.

1.3. Purpose and Hypotheses of the Present Study

Previous research, which, with the exception of the study of Kambanaros et al. (2018), is mainly focused on the English language, suggests that there is significant variability in the lexical–semantic performance of children with HF-ASD, while no single factor, such as age, IQ, vocabulary task type, or language performance, has been identified as the crucial factor in the shaping of lexical semantic skills, although the bulk of studies evaluated lexical semantic abilities using only one vocabulary task (Sukenik and Tuller 2023). Generally, but not universally, children with ASD and broader LIs show impaired lexical semantic skills, while children with ASD without LIs show similar or even enhanced lexical skills to those of their TD peers (McGregor et al. 2012; Sukenik and Tuller 2023; Vogindroukas et al. 2022; Walenski et al. 2006, 2008). The purpose of this study is to compare two groups of Greek-speaking, age-matched, gender-matched, and non-verbal IQ-matched children, one with HF-ASD and mild LIs and one of TD children, in two vocabulary-related measures: vocabulary size and vocabulary depth. Based on previous findings, albeit most of which are in languages other than Greek, it is hypothesized that children with HF-ASD and a mild LI are expected to have equal or even superior naming abilities (a task measuring vocabulary size) compared to their TD peers, but that they will lag behind in the word definition task (a task measuring vocabulary depth), as this task requires a more sophisticated and thorough understanding of word-to-word relationships. Furthermore, the study examines the correlations between vocabulary measures (size and depth) and other language skills, such as morpho-syntactic, narrative, and overall language skills, separately in the two groups of children tested to investigate possible different patterns of language acquisition. Finally, the current study sets out to examine which of the independent variables of the experiment, namely "age", "group (ASDLI vs. TD)", "story-retelling performance" and "naming ability performance" may be the strongest predictor of performance in the word definition task, which examines vocabulary depth. In the analysis we present individual scores and group scores for the two vocabulary variables. To the best of our knowledge, this is the first study that addresses these issues in a language other than English. Specifically, the research questions of the study were formulated as follows:

1. Will the HF-ASD and mild LI children's performance in naming be comparable to that of their TD peers?
2. Will the HF-ASD and mild LI children's performance in the word definition task be poorer than that of their TD peers?
3. Will the children with HF-ASD and mild LI display a different pattern of language acquisition compared to their TD peers?
4. Will the morpho-syntactic ability of participants (HF-ASD and mild LI, as well as TD) be associated with their performance in the word definition task?
5. Will the overall language ability of participants (HF-ASD and mild LI, as well as TD) be associated with their performance in naming and word definition tasks?

2. Methodology

2.1. Participants

The participants in the study were 55 monolingual school-aged Greek-speaking children aged seven to ten, all of whom, in accordance with parental reports, had hearing acuity and no evidence of neurological impairment, and attended regular elementary schools or regular elementary schools with an inclusion class. These participants were non-randomly assigned to either the TD or the HF-ASDLI group. The participants with HF-ASDLI (mean age = 8.0 years, SD = 1.04, n = 25) were recruited from a public clinic specializing in ASD. Most of them are frequently re-evaluated in this clinic and had initially received a formal diagnosis of either Asperger's syndrome or a pervasive developmental disorder not otherwise specified, according to the International Classification of Diseases'

tenth revision (ICD-10; World Health Organization 1990) criteria, by an experienced child psychiatrist specialized in ASD. They also complied with the criteria for ASD without an accompanying intellectual impairment (Level 1) according to the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5; American Psychiatric Association 2013). All had typical intelligence (IQ > 70), as measured by the Greek version of Raven's Coloured Progressive Matrices (CPM) (Sideridis et al. 2015) and presented adequate verbal skills at least at the level of four- to five-word utterances. TD children (mean age = 8.43 years, SD = 0.83, n = 25) who were recruited from regular elementary schools, had a free educational and language history record, a non-verbal IQ > 70 according to CPM, and raw scores below 11 in the Greek translated version of the Social Communication Questionnaire (SCQ) (Zarokanellou et al. 2017), as completed by their parents. The SCQ was used to ensure that TD children in the control group did not exhibit autistic traits. Of the 55 participants, 5 were excluded because they did not meet the criteria of the study. Finally, two groups of 25 participants each were formed, matched in age, gender, and non-verbal intelligence, but with a statistically significant difference in the total SCQ raw score, as expected. Table 1 illustrates the participants' characteristics.

Table 1. Characteristics of study participants.

Group	TD Group (n = 25)	HF-ASDLI Group (n = 25)	*p*-Value
Age range (years; months)	7;4–9;11	7;0–10;0	
Age (years), mean (SD)	8.43 (0.83)	8.40 (1.04)	0.901
Sex, N (%)			
Boys	16 (64.0)	18 (72.0)	0.544 $^{+}$
Girls	9 (36.0)	7 (28.0)	
IQ, mean (SD)	105.5 (11.4)	101.6 (13.2)	0.272
Total SCQ raw score	6.24 (2.85)	16.68 (7.57)	<0.001

Student's *t*-test, $^{+}$ Pearson's $\chi 2$ test; TD = typically developing; HF-ASDLI = high-functioning autism spectrum disorders with language impairment; SCQ = Social Communication Questionnaire; RS = raw score, SD = standard deviation.

2.2. Assessment Tools

2.2.1. Assessment of Lexical Size: The Expressive One Word Picture Vocabulary Test-Revised (EOWPVT-R) (Kotsopoulos 2003)

The Greek translation and adaptation of EOWPVT-R was used to evaluate naming ability. The EOWPVT-R is a quick and easily administered tool consisting of 100 words presented through line drawings, which measures expressive vocabulary in TD children of 2–12 years old. The target-= words comprise mainly high-frequency and low-frequency nouns (objects such as "wheel" and "hexagon", or category labels such as "clothing" and "furniture") and fewer verbs, (e.g., "watch", "sew"). For the Greek language, there is no standardized naming test for children over the age of seven; however, a preliminary study revealed that the Greek version of the EOWPVT-R used in this experiment is valid for assessing expressive vocabulary in TD children aged 7 to 10 years old (Zarokanellou and Vlassopoulos 2015). Children were given one point for naming each target word correctly, while wrong answers received zero points. Consequently, for this test, the minimum possible raw score was zero points, whereas the possible maximum raw score was 100 points. In the current study, raw scores and age equivalents were used for the comparisons between the groups.

2.2.2. Assessment of Lexical Depth: The Athina Vocabulary Scale (Paraskevopoulos et al. 1999)

This measure consists of 20 words, which are orally presented to the child by the examiner for each of which the child is required to provide a verbal definition. These words examine the understanding of concrete and abstract nouns, such as, respectively, "apple" and "damage"; adjectives, such as "wise" and "powerful"; and verbs, such as "observe" and "neglect". To evaluate the depth of word knowledge, each definition is scored based on the amount of information included, according to the guidelines of the test. The manual

gives several paradigms and certain criteria for the assessment of each response. Definitions receive a zero score for incorrect or insufficient information, one point for information that includes some of the less important semantic characteristics of the target word, and two points if the information provided includes a synonym, a correct metaphorical meaning of the word, a less frequent polysemous meaning (e.g., for the word "observe", the answer "remark" receives two points), or a superordinate characteristic of the word; for example, the category of the word or the main and more frequently used semantic characteristics of the word (e.g., for the word 'apple', the answer 'fruit' receives two points). The maximum raw score is 40 points. The scale is standardized in Greek for TD children aged 5 to 10 years old and provides raw scores, standard scores, and age equivalents.

2.2.3. Assessment of Morphosyntax: The Action Picture Test (APT) (Vogindroukas et al. 2011)

This test is the Greek standardized version of the Action Picture Test (Renfrew 1997), consisting of two subscales that assess the content/informational competence and morpho-syntactic skills of TD children aged 4 to 7 years old. Content/informational or pragmatic competence refers to the ability of each child to describe the important information from the picture stimuli of the test, in association with the questions provided by the examiner. The morpho-syntactic subscale evaluates the correct use of various grammatical phenomena such as verb tenses, the number of nouns, subject-verb agreement, the use of a subordinate clause with the appropriate conjunction, and definite articles. The maximum raw score according to the test manual for the content/informational subscale is 50, while for the morpho-grammatical scale it is 66. The total raw scores of both subscales indicate the overall language ability of each child. In Greek-speaking TD children, their morphological and syntactic abilities are almost fully developed by the age of around seven or even earlier (Terzi et al. 2014). In the current study, the APT was used to ensure that ASDLI participants had sufficient morpho-syntactic abilities and pragmatic skills to produce sentences and answer questions with ease.

2.2.4. Assessment of Narrative Ability: Two Narrative Tasks from the Test of Language Comprehension and Expression (Vogindroukas and Grigoriadou 2009)

The children's narrative skills were assessed through two structured informal tasks: a story-telling task with picture sequence use (storytelling with PSU) and a story-retelling task. These tasks are part of the Test of Language Comprehension and Expression (Vogindroukas and Grigoriadou 2009), which is the translation and adaptation into Greek of the Picture Test of the Derbyshire Language Schemes (Knowles and Masidlover 1982). The story-telling task with PSU consists of five black and white picture drawings that depict a child getting ready to go to school. In this task, the children were asked to put the cards in sequential order and tell the story. In the story-retelling task, the children first heard a short story read by the examiner and then had to retell it as accurately as possible. The theme of the story differed according to the gender of each child, to trigger their interest. Both selected tasks are culturally appropriate and compatible with the age range of participants of the current study to elicit adequate language samples. Relevant research suggested that tasks and materials can impact the narrative ability of examinees and that there are cultural variations in the development of the narrative ability of children, which reflect the cultural style of their community and its socio-cultural norms (Norbury et al. 2014; Westerveld et al. 2023). Research on the narrative skills of children with ASD showed that narratives are valuable and sensitive tools for the assessment of language ability in children with ASD; mild language deficits beyond the level of sentences are not always detectable through the administration of standardized language tests targeting the lexical or sentential level, whilst narrative ability itself correlates significantly with lexical, syntactic, and pragmatic skills, and is shown to be a valid indicator of persistent LIs (Norbury et al. 2014).

Narrative transcription and coding: The primary author, an Speech Language Therapist (SLP) with more than 9 years of clinical experience with children with neurodevelopmental disorders, transcribed and coded, according to the predefined microstructure and

macrostructure criteria of the study, all narrative productions. Each narrative was also assessed by an independent PhD-certified speech-language pathologist with more than 30 years of clinical experience, who was blinded to the diagnosis of each participant. The microstructure criteria included (a) the use of conjunctions (Manolitsi and Botting 2011; Ralli et al. 2021), (b) the use of semantically and pragmatically appropriate vocabulary, such as correct adjectives (e.g., "beautiful", "red", "blonde" for the noun "hair"), adverbs of time, place or manner (e.g., "then", "after"), mental state and emotion words (e.g., "love", "be", "like", "happy", "cry") (Manolitsi and Botting 2011; Ralli et al. 2021), and (c) the accurate use of morpho-syntax (Manolitsi and Botting 2011). The selection of microstructure variables for analysis was based on conclusions from previous studies. As for conjunctions, the use of zero to one connector was awarded 0 points, the use of two connectors 1 point, and the use of three or more connectors in each narrative was awarded 2 points. The macro-skills criteria were (a) story structure (the ability to produce a cohesive narrative, i.e., the correct use of cohesive devices) and (b) the understanding of the cause and consequence relationship in the plot of each story (Manolitsi and Botting 2011; Ralli et al. 2021). Each component of these micro and macro narrative skills was assessed with 0, 1, or 2 points, giving a total possible score of 10 points for each narrative task. If a participant could not retell the story, the examiner asked five simple questions related to the story, according to the test manual. Each correct answer was awarded 1 point, while every wrong or irrelevant answer received 0 points. For the current study, the total raw scores were used for each narrative task.

2.3. Procedure

A quasi-experimental comparative group design was employed to compare (a) differences in the test scores of vocabulary size and depth and (b) the magnitude and direction of the correlations between the vocabulary variables of size and depth with the other language skills (morpho-syntactic, narrative, and overall language ability) in children with HF-ASD and mild LIs and their TD peers, in order to investigate the possibility of different language acquisition patterns in these two child populations. The study's protocol was approved by the Greek Institution of the Educational Policy (number of approval 53/2-09-2014) and the Ethical Committee of the Medical School of Athens (number of approval 8067/11-06-2012). Participation in the study was voluntary. Before the assessment of the children, all caregivers gave their written consent and completed the Greek translation of the SCQ, to ensure that participants with possible ASD symptomatology (raw score $\geq$ 11) were excluded from the TD group (Zarokanellou et al. 2017). Participants with a non-verbal IQ < 70 were excluded from the study (Sideridis et al. 2015). Since, at present, there are no available standardized language measurements in Greek for school-age children older than seven years old (Kambanaros et al. 2018; Manolitsi and Botting 2011), for the selection of the ASD-LI participants, a language assessment protocol was administered which, besides the formal diagnosis by an experienced child psychiatrist specializing in ASD, was based on the following: previous developmental history information, informal testing results for language comprehension and production according to the Greek Test of Language Comprehension and Expression (Vogindroukas and Grigoriadou 2009), results from the administration of the Greek standardized version of the Action Picture Test (Vogindroukas et al. 2011), language sample analyses, and clinical observations of language performance. The above procedure aimed to ensure that the characterization of the HF-ASDLI group was reliable and valid. Besides the language protocol, two vocabulary tasks, a naming task, and a definition task were also administered in a counterbalanced order. The assessment procedure was undertaken by an MSc-certified speech-language pathologist, with at least 9 years of clinical experience in neurodevelopmental disorders, during two hourly sessions in a quiet room. Participant responses were recorded and subsequently transferred to the corresponding answer sheets.

2.4. Statistical Analysis

Normally distributed variables were expressed as mean and standard deviation (SD). The nominal variable of gender was expressed as absolute and relative frequencies. The

normality assumption was evaluated using the Kolmogorov–Smirnov test ($p > 0.05$). For the comparisons of the categorical variables, Pearson chi-square tests were used. For the between-group comparisons of the continuous variables, the Student's *t*-test was used. In cases where there was no normal distribution, the Mann–Whitney U test was computed. More specifically, for the between-group comparisons, regarding the mean scores for the variables of age, non-verbal IQ, total SCQ raw score, EOWPVT-R raw score, Athina vocabulary test raw score, APT grammatical skills raw score, APT informational competence raw score, and APT language total raw score, the Student's *t*-test was used, while for the between-group comparisons, regarding the telling of a story with PSU total raw score and the story-retelling total raw score, the non-parametric Mann–Whitney U test was computed. The effect sizes were computed using Cohen's d coefficient (Cohen 1998).

A Pearson correlation coefficient (r) was used to test the association of measures between each of the two vocabulary measures (the EOWPVT-R and Athina vocabulary test) and APT grammatical skills, APT informational competence, APT language total score, telling a story task with PSU, and the story-retelling task. Also, the Pearson coefficient was applied to examine the correlation between scores in the vocabulary size task and in the vocabulary depth task, since previous studies (Schmitt 2014) with TD children have reported a positive and strong association between these vocabulary variables.

Moreover, a logistic regression analysis was performed to examine the effect of the independent variables of "age", "group (HF-ASDLI vs. TD)", "story-retelling performance" and "naming ability performance" (i.e., vocabulary size) on the total scores of the vocabulary depth test (dependent variable). Additionally, a power analysis for the sample size was computed, with the desirable power level to be set over 0.80. The power analysis returned a score of 0.84.

The inter-rater reliability of the narrative scores between two independent examiners was calculated using intraclass correlation coefficients (ICCs) (Landis and Koch 1977). Finally, for the estimation of the abnormality of each ASD participant's raw scores in the naming and word definition tasks, the following analyses were performed against the mean raw scores of the control group: the modified *t*-test described by Sokal and Rohlf, the point estimate of the effect size (Zcc), and the 95% interval estimate of effect size, as well as point estimates and 95% confidence limits on the percentage of the population falling below the mean raw scores of the control group. All *p*-values reported are two-tailed. Statistical significance was set at 0.05 and analyses were conducted using SPSS statistical software (version 22.0, Armonk, NY, USA) and the RStudio v.2022.02.3 Build 492 (RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA, USA, URL http://www.rstudio.com/ (accessed on 15 December 2023)).

3. Results

3.1. Language Skills of Participants

Although the HF-ASDLI and control group did not differ in content/informational and grammatical abilities, according to the Greek version of APT, which is standardized for TD children aged 4 to 7 years old, they did show significant differences in narrative tasks with small to moderate effect sizes, results which indicate that the group with HF-ASD presented mild LIs. The interclass correlation coefficients (ICC) between the two independent examiners for the narrative tasks were excellent (0.96–1.00). Analytically, the ICC for the telling a story with PSU was equal to 0.99 (confidence interval 0.98–1.00, $p < 0.001$), while, for the story-retelling task, the ICC was 0.98 (confidence interval 0.96–0.99, $p < 0.001$).

3.2. Size and Depth of Vocabulary Knowledge

As was expected, the statistical analysis did not reveal significant differences between the two groups in the naming abilities. However, the children with HF-ASDLI exhibited notable difficulty in producing appropriate definitions of words with high effect sizes (Table 2), even though they had sufficient language skills to describe the essential information in the APT picture stimuli, as is shown by the relevant APT scores. Relevant data are presented in Table 2.

Table 2. Language abilities of participants.

	Group				
	TD Group n = 25	**HF-ASDLI Group n = 25**	***p*-Value**	**Cohen's d Effect Size**	**Cohen's d Confidence Intervals 95% CI**
Raw score, mean (SD) Range					
EOWPVT-R (max. RS = 100)	65.7 (7.5) 53–79	59.7 (15.2) 21–82	0.082	−0.50	−1.062 to 0.064
Athina vocabulary test (max. RS = 40)	27.2 (6.7) 13–36	20.0 (10.5) 0–38	0.006	−0.82	1.389 to 2.233
APT grammatical skills (max. RS = 66)	49.3 (7.2) 30.0–64.0	45.2 (12.9) 22.0–64.0	0.179	−0.39	−0.943 to 0.176
APT informational competence (max. RS = 50)	39.8 (4.7) 27.0–48.0	35.7 (10.8) 10.0–46.0	0.088	−0.49	−1.054 to 0.072
APT language total score (max. RS = 116)	89.5 (10.8) 57.0–109.0	81.0 (23.1) 32.0–110.0	0.100	−0.47	−1.035 to 0.090
Telling a story with PSU total score (max. RS = 10)	8.9 (1.2) 5–10	6.7 (2.4) 4–10	<0.001 ‡	−1.17	−1.769 to −0.565
Story retelling total score (max. RS = 10)	9.2 (1.2) 6–10	7.4 (2.7) 4–10	0.002 ‡	−0.85	−1.424 to −0.265
Age equivalent (months), mean (SD) Range					
Athina vocabulary test (max. age range = 135)	107.1 (15.4) 74–127	90.4 (24.8) 40–131	0.006	−3.48	2.585 to 4.362
EOWPVT-R (max. age range = 144)	103.7 (16.5) 80–140	96.4 (27.5) 40–143	0.260	−0.32	−0.879 to 0.237

Student's *t*-test; ‡ Mann–Whitney U test; TD = typically developing; HF-ASDLI = high-functioning autism spectrum disorder with language impairment; RS = raw score; SD = standard deviation; Cohen's d effect sizes: 0.2–0.5 small; 0.51–0.8 moderate, >0.8 large.

The comparison of each ASD participant's raw scores in the naming task (EOWVT-R) against the mean raw scores of the control group, revealed that four ASD participants with the IDs 4, 5, 6, and 14 scored significantly lower than those of the control group, the effect sizes were very large, and the case's scores were highly abnormal, indicating that only a really small percentage of the control population would be expected to exhibit as poor a naming performance as these participants. Moreover, one ASD participant (ASD ID 12) exhibited enhanced naming skills, compared to the mean raw scores of the control group, while in this case the effect sizes were large and the scores were abnormal, with only 0.189 to 7.461 percent of the control population expected to present as good a naming performance as this participant (see Appendix A). On the contrary, the comparison of ASD participants' raw scores in the word definition task (Athina test) against the mean raw scores of the control group showed that eight ASD participants presented significantly lower scores than the control group, with the effect sizes being very large, making the individual scores in these particular cases highly atypical, since only a small percentage of the control group is expected to present word definition abilities as low as these (for relevant information see Appendix B). The analysis also showed that 15 out of the 25 participants with HF-ASD and mild LIs presented a significantly lower age-equivalent performance in the word definition task (Athina Test), lagging behind their chronological age by a range of 8 to 46 months.

We also examined the correlation between vocabulary size and vocabulary depth. We found a positive and strong correlation between the two variables for raw scores (ASD: r = 0.82, $p < 0.001$, TD: r = 0.73, $p < 0.001$) and age equivalents (ASD: r = 0.83, $p = 0.001$, TD: r = 0.74, $p < 0.001$) in both groups (See Figure 1).

3.3. Associations between Vocabulary Size and Depth and Other Language Skills

Pearson's correlation coefficients (r) were used to investigate the relationship between lexical, semantic, and other language skills. We treated language variables as continuous variables. Furthermore, using the Pearson's correlational statistical analysis, we wanted

to compare the language acquisition patterns between the HF-ASDLI group and the TD group. The results are presented in Table 3.

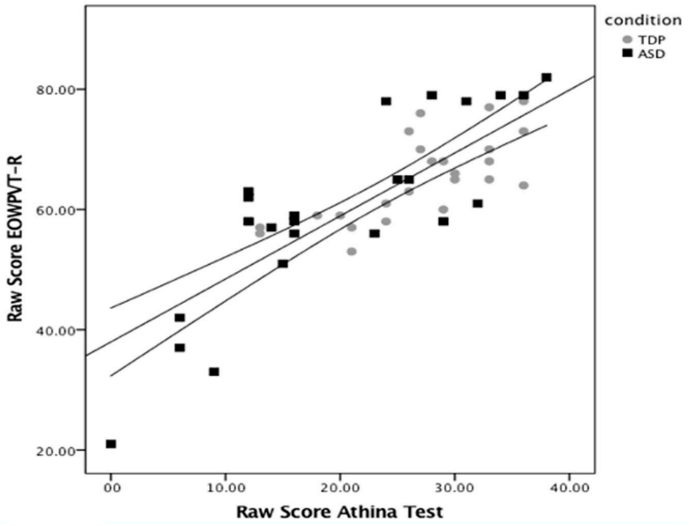

Figure 1. Correlation between vocabulary size and vocabulary depth.

Table 3. Correlations between expressive vocabulary tasks and other language variables.

	TD Group					
	EOWVT-R		**Athina Test**			
	Raw Score		**Raw Score**		**Age Equivalent**	
	r	*p*	*r*	*p*	*r*	*p*
Action Picture Test						
Grammatical skills	0.450	0.025	0.520	0.008	0.520	0.008
Informational competence	0.350	0.083	0.340	0.100	0.330	0.107
Language total score	0.480	0.015	0.530	0.006	0.530	0.007
Telling a story with PSU	0.200	0.339	0.120	0.590	0.134	0.523
Retelling a story	0.380	0.061	0.460	0.022	0.450	0.023
	HF-ASDLI Group					
Action Picture Test						
Grammatical skills	0.490	0.013	0.480	0.014	0.500	0.011
Informational competence	0.61	0.001	0.540	0.005	0.560	0.004
Language total score	0.560	0.003	0.520	0.007	0.54	0.005
Telling a story with PSU	0.120	0.538	0.110	0.604	0.037	0.862
Retelling a story	0.388	0.050	0.368	0.048	0.345	0.045

For both groups, a significant positive correlation was detected between vocabulary depth and the grammatical subscale of the APT (see Figure 2), as well as between vocabulary size and the grammatical subscale of the APT.

Also, in both groups, there was a significant and positive correlation between the two lexical variables (vocabulary size and depth) and the overall language ability, which was measured by the total score of the APT. Moreover, the two vocabulary variables (lexical size and depth) were significantly and positively associated with informational abilities, as measured with the APT, in the ASD group (EOWPVT-R: r = 0.61, p = 0.001, Athina vocabulary scale: r = 0.54, p = 0.005) but not in the TD group (EOWPVT-R: r = 0.35, p = 0.083, Athina vocabulary scale: r = 0.34, p = 0.100). Furthermore, the statistical analysis returned a marginally positive significant association between the two vocabulary variables (vocabulary size and depth) and the story-retelling task for the ASD group (EOWPVT-R: r = 0.388, p = 0.05, Athina vocabulary scale: r = 0.368, p = 0.048), but only vocabulary depth significantly correlated with this task for the TD group (r = 0.46, p = 0.022). The above findings show that language skills correlate significantly with semantic knowledge.

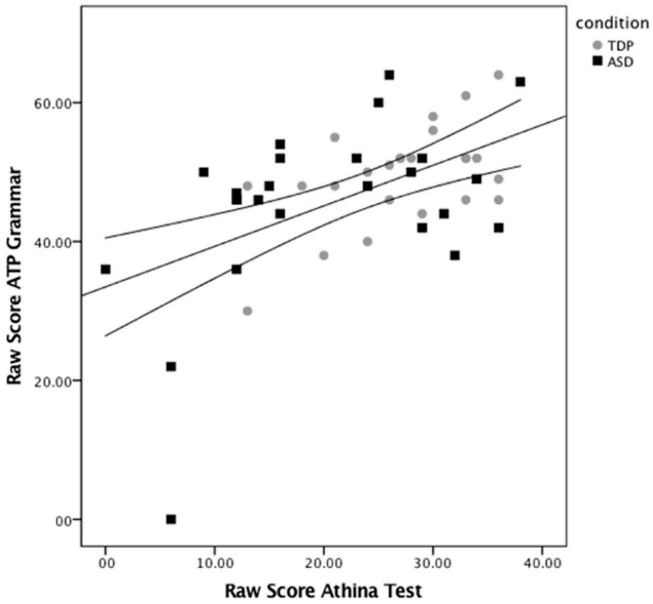

Figure 2. Correlation between raw scores of ATP grammar scale and Athina vocabulary Test.

Finally, in order to investigate how age, group (HF-ASDLI vs. TD), language skills as measured by narrative ability in the story-retelling task, and vocabulary size (performance in EOWPVT-R) affect performance on the Athina vocabulary scale, a logistic regression analysis was performed. The regression analysis returned the following: the variable "group" ($\beta = 2.278$, t (1) = 50.000, $p < 0.001$) and the variable "story-retelling performance" ($\beta = 0.374$, t (1) = 7.895, $p = 0.005$) significantly predicted the Athina test scores. The results indicated that there was a significant association between the "group" and "story-retelling performance" variables and the Athina test performance $\chi 2(4) = 69.315$, $p < 0.001$ with Nagelkerke $R^2 = 0.950$.

4. Discussion

In this study, we examined vocabulary size and vocabulary depth in Greek-speaking children with HF-ASD and mild LIs. Our results agree with the data from research in languages such as English, in that, generally, children with HF-ASD and advanced verbal speech have naming abilities equal to those of their neurotypical peers (Eigsti et al. 2007; Lucas et al. 2017; Norbury et al. 2010). Previous studies also showed that children with HF-ASDLI face significantly greater difficulties in the production of definitions, as this task requires more in-depth knowledge of word-to-word relationships, which elaborates to a greater extent the integration of the semantic and morphosyntactic information of sentences (Kambanaros et al. 2018; Lucas et al. 2017; McGregor et al. 2012). Our results are in line with previous data, showing that, even though our HF-ASDLI group equally demonstrated adequate expressive morphosyntactic and language skills to answer a given question about a picture stimuli, the definitions produced were more superficial and immature than those of the TD group. We investigated further the effect of age, group (HF-ASDLI vs. TD), story-retelling performance (narrative skills), and the naming abilities of participants on the total scores of the Athina vocabulary depth test. The variables of "group" and "narrative ability" (story retelling) significantly affected the production of definitions, indicating that language skills modulate the performance of participants in the production of definitions task. The results are interesting for two reasons. Firstly, they highlight the close relationship of lexical and overall language development, indicating inter alia that underlying deficits in the knowledge of syntax may affect the performance of participants in semantic tasks, such as the production of definitions, that depend heavily on the refined understanding of word-to-word relationships, even when children with HF-ASD present mild language deficits. Secondly, they emphasize the importance of using narrative tasks as a sensitive indicator for language development in children with HF-ASD, since mild language deficits are not always detectable

through the use of standardized language tests that assess the language skills of children with ASD at sentence level. Previous researchers (McGregor et al. 2012; Lucas et al. 2017; Norbury 2005) who examined lexical knowledge in participants with ASD with and without LIs and in their TD peers used the scaled scores on the syntactic subtests of the Clinical Evaluation of Language Fundamentals-4 (Semel et al. 2003) as a reference criterion for the diagnosis of LIs, but the CELF-4 test is not standardized in Greek or in other languages. At this point, it is appropriate to note that morphosyntactic development in Greek is complete at about the age of seven or even earlier, according to the findings of research like that of Terzi et al. (2014). After this age, Greek-speaking TD children express more sophisticated ideas, using sentences that are more complex with more conjunctions; thus, the above suggests that syntactic complexity is still developing, but new syntactic structures are not necessarily being acquired; rather, the already acquired ones are used for the production of more complex macro-structures. Additionally, Kambanaros et al. (2018) proposed that overall language skills correlate significantly with the ability of children with HF-ASD to explain the meaning of words and that, while global language abilities in Greek-speaking children with HF-ASD aged between 6;3 and 8;9 years old improve with maturation, they are outside the TD norms. Our results are in accordance with the findings of Kambanaros et al. (2018), who reported that Cypriot-Greek bidialectal children with HF-ASDLI underperformed in the production of definitions for compositional noun–noun compound words, in relation to their TD peers.

Another possible explanation for the discrepancy between the performance in naming tasks and production of definitions tasks in children with HF-ASD and advanced language skills may relate to the psycholinguistic features of word stimuli presented in each task. It is possible that the definition tasks use more difficult word categories than the naming tasks, as the former can include more abstract, less frequent, and less imageable concepts. In particular, the definition task used in the present study was relatively demanding for the participants with ASD, as it presented difficult word categories, such as abstract word concepts (e.g., "wise"), complex verbs (e.g., "neglect") and emotion words (e.g., "sorrow"). According to research in the English language, these word categories are particularly challenging for individuals with ASD, since participants with ASD have significant difficulty in understanding emotion words and abstract verbs and consequently in producing in-depth definitions (Moseley et al. 2013, 2015). In addition, Kambanaros et al. (2018) suggest that a word's 'imageability' correlates significantly with the explanatory abilities of children with HF-ASD: specifically, the more imageable the word is, the better children with ASD can explain its meaning. Furthermore, we examined the correlation between our two vocabulary variables (size and depth) and found a positive strong correlation for both our groups, a finding which agrees with those of other studies in different languages (Schmitt 2014).

Finally, we examined in greater detail the link between the two vocabulary variables (size and depth) and other language skills (morpho-syntax, narrative ability, and overall language ability), since previous research argues that an intact morphosyntactic ability helps children to learn the meaning of words (McGregor et al. 2012). Previous researchers (Tek et al. 2014) reported that children with HF-ASD and language deficits may present different language acquisition patterns from those of their TD peers. The results revealed that both vocabulary variables (vocabulary size and vocabulary depth) were significantly positively correlated with grammatical skills and overall language ability according to the APT, supporting previous results from other studies (Kambanaros et al. 2018; Lucas et al. 2017; McGregor et al. 2012; Norbury 2005). Moreover, vocabulary depth, as measured with the Athina Test, was significantly positively correlated with narrative performance (story-retelling task) in both groups, while vocabulary size (EOWPVT-R) was only marginally significantly positively correlated with story-retelling performance in the HF-ASDLI group, but not in the TD group. The above results appear to be perfectly reasonable, since the mastery of both the production of definitions and narrative retelling skills entails linguistic, lexical, syntactic, and pragmatic skills, as well as cognitive abilities such as the following: adequate selective attention and working memory to encode the given verbal instructions and information, the capacity to extract the essence of the information,

the ability to organize a set of events sequentially, and the ability to incorporate non-linguistic and linguistic stimuli to create a novel unit of discourse. All these rely on complex socio-cognitive skills such as perspective-taking and Theory of Mind, in which children with HF-ASD present significant deficits (Arunachalam and Luyster 2016; Norbury et al. 2014). A significant positive correlation was also found between the two vocabulary constructs (size and depth) and the informational competence subscale of the APT, but only in the HF-ASDLI group. These results, in addition to the marginally positive significant correlation between the vocabulary size and the story-retelling task in the HF-ASDLI group, may indicate that the children with HF-ASDLI depend more heavily on their ability to comprehend words to extract the essence of the information, and have a less well-developed ability to decontextualize and more flexibly use previously acquired word knowledge, compared to their TD peers. The above findings are in line with the results of Norbury's study (Norbury 2005), which suggests that children with HF-ASDLI have difficulties with the use of context to facilitate lexical ambiguity.

Limitations of the Study

Owing to a lack of appropriate standardized tools in Greek, we were not able to explore in greater depth the associations between syntactic abilities and word knowledge, nor were we able to use an ASD group without LIs to compare performances between different ASD groups, as other researchers were able to in their studies (Norbury 2005; McGregor et al. 2012; Lucas et al. 2017). These constitute directions for future investigation. Additionally, a criterion-referenced assessment task evaluation of the production of definitions in different classes of words, such as abstract nouns, emotion words, verbs, compound words, temporal terms, etc., which seem to present a greater challenge for children with HF-ASD, would also be useful.

5. Conclusions

The current study revealed that school-age children with HF-ASD and mild LIs continue to face qualitative deficits in vocabulary knowledge and have more immature lexical representations than their TD peers. Although this result has been found in other studies, our research, based on a language other than English, adds to this body of knowledge, as it gives an indication that vocabulary difficulties in this population are not a language-specific deficit, but constitute part of a broader language phenotype in autism. Consequently, speech-language intervention programs could place particular emphasis on the organization of semantic networks from simpler to more complex concepts, according to certain semantic and psycholinguistic features of the word stimuli, such as content, frequency, imageability, concreteness, and the number of acceptable meanings, including tasks such as production of definitions and compound words, antonyms, synonyms, and language analogies, which seem more challenging for children with HF-ASD.

Author Contributions: Conceptualization, V.Z.; methodology, V.Z., A.P. and D.T.; formal analysis, D.T.; investigation, V.Z. and K.P.; resources, V.Z. and A.P.; data curation, V.Z.; writing—original draft preparation, V.Z.; writing—review and editing, V.Z., A.P. and G.K.; visualization, V.Z.; supervision, K.P.; project administration, G.K.; funding acquisition, D.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Medical School of National and Kapodistrian University of Athens (protocol code 8067 and date of approval 11-06-2012).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Additionally, written informed consent was obtained from the patient(s) to publish this paper.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Comparing HF-ASDLI participant's raw scores to TD controls in the EOWVT-R.

HFASD-LI Group		TD Group			Significant Test [a]		Estimated Percentage of Control Population Obtaining a Lower Score than ASD Participant [b]		Estimated Effect Size (zcc) [c]	
ASD ID	**Case's Raw Scores on EOWPVT-R**	**n**	**Mean**	**SD**	**t**	***p***	**Point**	**95% CI**	**Point**	**95% CI**
1	57	25	65.7	7.5	−1.143	0.264	13.215	4.749 to 25.924	−1.166	−1.670 to −0.646
2	58	25	65.7	7.5	−1.012	0.322	16.083	6.501 to 29.598	−1.032	−1.514 to −0.536
3	58	25	65.7	7.5	−1.012	0.322	16.083	6.501 to 29.598	−1.032	−1.514 to −0.536
4	21	25	65.7	7.5	−5.862	<0.001	0.000	0.000 to 0.001	−5.978	−7.652 to −4.248
5	37	25	65.7	7.5	−3.765	0.001	0.048	0.000 to 0.362	−3.839	−4.983 to −2.685
6	33	25	65.7	7.5	−4.289	<0.001	0.013	0.000 to 0.104	−4.374	−5.660 to −3.078
7	51	25	65.7	7.5	−1.930	0.066	3.278	0.415 to 9.997	−1.968	−2.640 to −1.282
8	63	25	65.7	7.5	−0.357	0.725	36.227	22.196 to 51.850	−0.364	−0.766 to 0.046
9	58	25	65.7	7.5	−1.012	0.322	16.083	6.501 to 29.598	−1.032	−1.514 to −0.536
10	56	25	65.7	7.5	−1.274	0.215	10.741	3.367 to 22.502	−1.299	−1.829 to −0.755
11	59	25	65.7	7.5	−0.881	0.387	19.356	8.718 to 33.567	−0.898	−1.358 to −0.424
12	82	25	65.7	7.5	2.134	0.043	2.163	0.189 to 7.461	2.176	1.442 to 2.896
13	56	25	65.7	7.5	−1.274	0.215	10.741	3.367 to 22.502	−1.299	−1.829 to −0.755
14	42	25	65.7	7.5	−3.109	0.005	0.239	0.002 to 1.423	−3.171	−4.139 to −2.191
15	62	25	65.7	7.5	−0.488	0.630	31.512	18.160 to 46.999	−0.497	−0.909 to −0.075
16	65	25	65.7	7.5	−0.094	0.926	46.280	31.269 to 61.705	−0.096	−0.488 to 0.298
17	58	25	65.7	7.5	−1.012	0.322	16.083	6.501 to 29.598	−1.032	−1.514 to −0.536
18	61	25	65.7	7.5	−0.619	0.542	27.097	14.526 to 42.271	−0.631	−1.057 to −0.195
19	78	25	65.7	7.5	1.610	0.121	6.027	1.249 to 15.208	1.642	1.028 to 2.242

Table A1. *Cont.*

HFASD-LI Group		TD Group			Significant Test [a]		Estimated Percentage of Control Population Obtaining a Lower Score than ASD Participant [b]		Estimated Effect Size (zcc) [c]	
ASD ID	Case's Raw Scores on EOWPVT-R	n	Mean	SD	t	*p*	Point	95% CI	Point	95% CI
20	78	25	65.7	7.5	1.610	0.121	6.027	1.249 to 15.208	1.642	1.028 to 2.242
21	58	25	65.7	7.5	−1.012	0.322	16.083	6.501 to 29.598	−1.032	−1.514 to −0.536
22	79	25	65.7	7.5	1.741	0.095	4.727	0.813 to 12.898	1.775	1.131 to 2.403
23	65	25	65.7	7.5	−0.094	0.926	46.280	31.269 to 61.705	−0.096	−0.488 to 0.298
24	79	25	65.7	7.5	1.741	0.095	4.727	0.813 to 12.898	1.775	1.131 to 2.403
25	79	25	65.7	7.5	1.741	0.095	4.727	0.813 to 12.898	1.775	1.131 to 2.403

TD = typical development; n = total number of children with TD, referred to as the control group; Mean = average score of the control group on naming task; SD = standard deviation obtained by the raw scores of the control group on naming task; HF-ASDLI = high-functioning autism spectrum disorder with language impairment; [a] Crawford and Howell (1998), results for one-tailed test; [b] Crawford and Garthwaite (2002); [c] Crawford et al. (2010).

Appendix B

Table A2. Comparing HF-ASDLI participants' raw scores to TD controls in the word definition task of the Athina Test.

HF-ASDLI Group		TD Group			Significant Test [a]		Estimated Percentage of Control Population Obtaining a Lower Score than ASD Participant [b]		Estimated Effect Size (zcc) [c]	
ASD ID	Case's Raw Score on Word Definition	n	Mean	SD	t	*p*	Point	95% CI	Point	95% CI
1	14	25	27.2	6.7	−1.933	0.065	3.255	0.410 to 9.968	−1.971	−2.643 to −1.283
2	16	25	27.2	6.7	−1.640	0.114	5.700	1.134 to 14.624	−1.673	−2.279 to −1.053
3	29	25	27.2	6.7	0.264	0.794	39.717	25.244 to 55.297	0.269	−0.133 to 0.667
4	0	25	27.2	6.7	−3.983	0.001	0.027	0.000 to 0.220	−4.062	−5.264 to −2.848
5	6	25	27.2	6.7	−3.105	0.005	0.242	0.002 to 1.440	−3.166	−4.134 to −2.186

Table A2. *Cont.*

HF-ASDLI Group		TD Group			Significant Test [a]		Estimated Percentage of Control Population Obtaining a Lower Score than ASD Participant [b]		Estimated Effect Size (zcc) [c]	
ASD ID	Case's Raw Score on Word Definition	n	Mean	SD	t	*p*	Point	95% CI	Point	95% CI
6	9	25	27.2	6.7	−2.665	0.014	0.677	0.018 to 3.200	−2.718	−3.572 to −1.852
7	15	25	27.2	6.7	−1.787	0.087	4.332	0.695 to 12.139	−1.822	−2.460 to −1.168
8	12	25	27.2	6.7	−2.226	0.036	1.783	0.129 to 6.500	−2.270	−3.014 to −1.514
9	29	25	27.2	6.7	0.264	0.794	39.717	25.244 to 55.297	0.269	−0.133 to 0.667
10	16	25	27.2	6.7	−1.640	0.114	5.700	1.134 to 14.624	−1.673	−2.279 to −1.053
11	16	25	27.2	6.7	−1.640	0.114	5.700	1.134 to 14.624	−1.673	−2.279 to −1.053
12	38	25	27.2	6.7	1.582	0.127	6.341	1.366 to 15.746	1.613	1.005 to 2.207
13	23	25	27.2	6.7	−0.615	0.544	27.214	14.611 to 42.416	−0.627	−1.053 to −0.191
14	6	25	27.2	6.7	−3.105	0.005	0.242	0.002 to 1.440	−3.166	−4.134 to −2.186
15	12	25	27.2	6.7	−2.226	0.036	1.783	0.129 to 6.500	−2.270	−3.014 to −1.514
16	26	25	27.2	6.7	−0.176	0.862	43.099	28.325 to 58.659	−0.179	−0.573 to 0.219
17	12	25	27.2	6.7	−2.226	0.036	1.783	0.129 to 6.500	−2.270	−3.014 to −1.514
18	32	25	27.2	6.7	0.703	0.489	24.443	12.448 to 39.401	0.717	0.269 to 1.153
19	24	25	27.2	6.7	−0.469	0.644	32.178	18.729 to 47.691	−0.478	−0.888 to −0.058
20	31	25	27.2	6.7	0.557	0.583	29.151	16.169 to 44.531	0.568	0.138 to 0.988
21	12	25	27.2	6.7	−2.226	0.036	1.783	0.129 to 6.500	−2.270	−3.014 to −1.514
22	28	25	27.2	6.7	0.117	0.908	45.385	30.381 to 60.893	0.119	−0.277 to 0.513
23	25	25	27.2	6.7	−0.322	0.750	37.505	23.313 to 53.086	−0.329	−0.729 to 0.077
24	34	25	27.2	6.7	0.996	0.329	16.463	6.738 to 30.099	1.016	0.522 to 1.496
25	36	25	27.2	6.7	1.289	0.210	10.489	3.243 to 22.176	1.314	0.766 to 1.846

TD = typical development; n = total number of TD children, referred to as the control group; Mean = average score of the control group in word definition task; SD = standard deviation obtained by the raw scores of the control group in word definition task; HFASD-LI = high-functioning autism spectrum disorder with language impairment. [a] Crawford and Howell (1998), results for one-tailed test; [b] Crawford and Garthwaite (2002); [c] Crawford et al. (2010).

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