CIENTIFIC Publishing Limited

Neurolinguistic Communication Intervention
https://ojs.ukscip.com/index.php/nci

Article

Mandarin-Speaking Monolingual Children with Autism Can Learn and Retain Foreign Language Words: A Longitudinal Study

Xin Kang [1,2,3,*], Yaqian Zhang [1,2,3], Ning Ding [1,2,3], Xiyu Hu [1,2,3], Xuanchi Chen [1] and Qiutong Liu [1]

[1] School of Foreign Languages and Cultures, Chongqing University, Chongqing 400044, China

[2] Research Centre for Language, Cognition and Language Application, Chongqing University, Chongqing 400044, China

[3] Key Laboratory of Hearing, Speech, and Cognition, Chongqing Municipal Health Commission, Chongqing 400013, China

[*] Correspondence: xin.kang@cqu.edu.cn

Received: 3 December 2025; **Revised:** 15 February 2026; **Accepted:** 22 February 2026; **Published:** 16 March 2026

Abstract: Bilingualism has long been linked with enhanced cognitive benefits, but parents of children with autism are often advised to use one language. One reason might be that there is limited evidence on the foreign language learning abilities of children with autism. This study investigated English word learning among monolingual Mandarin-speaking children with autism and typically-developing (TD) children using a longitudinal design. Participants were taught 48 English object names in a classroom-like setting over eight weekly sessions. Before starting the program, participants completed a pretest to calculate the percentage of target words they could identify and translate from English to Chinese. To measure their short-term learning outcomes, they completed an immediate learning test at the end of each session and a delayed test at the following session. Long-term retention was measured using final tests at one and five weeks after the learning program ended. Both groups showed stable weekly retention and comparable performance across sessions. Critically, children with autism achieved overall learning outcomes comparable to their typically developing peers. Nonverbal Intelligence Quotient (IQ) was associated with learning outcomes in both groups, whereas prior foreign language (L2) exposure was selectively associated with performance in children with autism. These findings provide preliminary evidence that children with autism can effectively learn and retain L2 words, challenging recommendations for monolingualism. Future studies should explore more complex linguistic domains, such as grammar and pragmatics, to further understand foreign language acquisition among children with autism.

Keywords: Autism Spectrum Disorder; Second Language Acquisition; Word Learning; Bilingualism; Foreign Language

1. Introduction

Children with autism demonstrate heterogeneity in their language abilities [1–4]. Despite impairment in social communication and interaction [2,5], some of them were reported to show comparable language abilities as their typically developing (TD) peers [3,6,7]. As inclusive education gains increasing attention worldwide, more children with autism are enrolled in mainstream schools [8–10] where they are expected to learn a foreign language (L2) alongside their TD classmates [11]. This reality stands in stark contrast to the long-standing clinical advice given to parents to raise their children with autism in a monolingual environment [12–14]. This recommendation stems from a now-outdated concern that bilingual exposure could cause confusion, impose an extra cognitive burden, or exacerbate difficulties in children with autism [15–17].

However, a growing body of evidence challenges this advice. Empirical studies have shown that some bilingual children with autism did not lag behind their monolingual peers with autism in language development [18–20]. Recent studies even revealed that bilingual children with autism showed advantages compared to monolingual children with autism in certain areas, such as focus production [21], expressive vocabulary size [22], functional vocabulary size [23], verbal fluency [24], narrative skills [25], and cognitive capacities [26], echoing the potential cognitive and linguistic benefits associated with bilingualism in the general population [27,28].

1.1. Word Learning among Children with Autism

A critical domain for examining foreign language learning is word learning, which is a fundamental component of language development [15,29–32]. Research in first language (L1) acquisition reveals a complex profile in children with autism. On the one hand, children with autism showed similar vocabulary developmental stages as their TD peers [7,33,34]. For example, like their TD peers, children with autism exhibited typical noun-dominant early lexicons [35]. Children with autism could also apply principles such as "mutual exclusivity" [36,37] and use social cues to map words to objects [38]. On the other hand, children with autism often learn new words less efficiently [7,34,39] and struggle with long-term retention [40]. They also have smaller sizes of receptive and expressive vocabulary than their TD peers [3,41–44], particularly for abstract nouns and pronouns [45,46].

Much of this evidence comes from highly controlled novel-word learning paradigms (e.g., [37–39, 47, 48]). While these laboratory-based studies provide valuable insights, they often lack ecological validity. Furthermore, many of these studies have focused primarily on immediate recall [7,48,49] or used short retention intervals ranging from 5 min [39] to 24 h [1] between learning and testing, which leaves a critical research gap in our understanding of long-term retention. While a few longitudinal studies have examined retention [50,51], they are typically limited by very small numbers of taught words or the absence of a TD comparison group, making it difficult to gauge children with autism's learning relative to their peers. For instance, Bosseler and Massaro [50] taught real vocabulary items to children with autism using a computer-animated agent named Baldi over six months. Eighty-four vocabulary lessons with 559 distinct vocabulary words drawn from school curricula, books, and image banks were delivered via a multimodal interface combining synthesized speech, written labels, and visual images. Learning outcome was assessed through immediate tests and a follow-up assessment 30 days later. They found that children with autism were able to learn new words, and 91% of the newly learned vocabulary was retained one month later. Norbury et al. [51] compared 13 children with autism and 13 TD peers who were matched on age, non-verbal IQ, and receptive vocabulary on novel word learning and retention. Participants learned four novel words (e.g., akidit, dentip) by six exposures. Then, using a computerized eye-gaze paradigm, a woman directed attention to the target object in biased trials (three times in a neutral condition and three in a biased condition). Accuracy rates and response times were recorded during the learning process. Three types of vocabulary tasks were administered immediately and again four weeks later: object naming, picture identification, and defining the target objects. Results showed that children with autism initially outperformed their peers in mapping phonological forms to novel referents, but this advantage diminished over time, whereas TD children showed sustained retention.

It is also important to note that word learning involves not only semantic mapping but also phonological encoding—the ability to store and later retrieve the sound forms of new words [52,53]. In typical development, newly learned phonological forms undergo consolidation over time, strengthening into stable lexical representations. In children with autism, evidence suggests that while initial phonological encoding may be intact, the consolidation of phonological representations over time may be less efficient than in TD peers [1,51]. This distinction is relevant for L2 word learning, where tasks requiring productive retrieval (e.g., picture naming) impose greater phonological demands than receptive tasks (e.g., picture identification).

Critically, research on L2 word learning in children with autism is even more limited [16,22,54]. The few existing studies, often single-case or small-group designs [11,55,56], confirm the potential for L2 acquisition but are severely limited by minimal sample sizes and a lack of control groups. Consequently, fundamental questions about whether children with autism can learn and retain L2 vocabulary as effectively as their TD peers in a naturalistic, classroom-based context remain unanswered. For example, Alemi et al. [55] investigated the effectiveness of humanoid robots in teaching English words to four Iranian children with autism. By comparing their scores at four timepoints—pretest, mid-test, immediate posttest, and delayed posttest (two weeks after learning)—this study revealed significant improvements in children's English word knowledge, with learning effects maintained after two weeks. Similarly, Zohoorian et al. [56] examined the effectiveness of the Picture Exchange Communication System (PECS) in English word instruction for two Iranian children with autism. The learning program consisted of 15 weekly sessions targeting 45 words, with repeated measurement showing progressive improvement in participants' vocabulary knowledge. In another study, Hu et al. [11] taught English vocabulary to three Mandarin-speaking preschool children with autism. They found that these children could learn English words in a small-group training.

Taken together, the existing research indicates that children with autism can acquire new words, but critical questions about their L2 learning abilities in real-world contexts remain unanswered. There are mainly three research gaps. First, many of these studies focused primarily on L1 word learning and used immediate recall, with fewer studies examining long-term retention. Second, although some studies employed longitudinal designs, they were mostly conducted in laboratory settings, which may not fully reflect the dynamics of group-based instruction that mirror mainstream classrooms. Third, while some recent studies have begun to explore L2 vocabulary learning in participants, most of these studies had small sample sizes and lacked comparison groups.

1.2. The Present Study

To address these limitations, the present study implemented a 13-week longitudinal L2 learning experiment to mirror a mainstream classroom. We investigated learning outcomes by measuring participants' performance at the end of the current session and a week later. Two post-tests were used as final tests for overall learning outcomes at the 9th week and 13th week. In addition, we examined how demographic factors and autism spectrum disorder (ASD) symptoms may influence participants' learning outcomes. We focused on three research questions:

(1) Do Mandarin-speaking children with autism demonstrate comparable L2 word learning outcomes as their TD peers?
(2) Can Mandarin-speaking children with autism retain L2 words as their TD peers over short and long-term intervals?
(3) To what extent do factors such as prior L2 exposure and nonverbal IQ influence their L2 word learning outcomes?

2. Method

2.1. Participants

40 Mandarin-speaking children participated in the study, including 25 children with autism and 15 TD children. Participants with autism were recruited via a local autism parent support group, while the TD participants were recruited through flyers distributed in local areas. The two groups were matched on the onset time for learning English at school. None of the participants were routinely exposed to English outside school. ASD status was confirmed with the administration of the Autism Diagnostic Observation Schedule 2nd Edition (ADOS-2) [57]. Nonverbal IQ was assessed using the Test of Nonverbal Intelligence 4th Edition (TONI-4) [58] or Primary Test of Nonverbal Intelligence (PTONI) [59] based on participants' chronological age. 37 participants above 6-year-old completed TONI-4 and 3 below 6-year-old completed PTONI. Parents completed questionnaires about demographic information. The study was conducted with the approval of the ethics committee of the university. Written informed consent was obtained from parents or caregivers of all participants.

Eleven out of the 40 participants were excluded for data analysis because they had a diagnosis of developmental language delay instead of autism. 3 children with autism missed more than three sessions out of eight sessions during the learning phase. 5 children with autism and 3 TD did not participate in the posttest at the 9th week or the 13th week. Furthermore, 2 children with autism did not meet the diagnostic criteria for ASD based on ADOS-2. Thus, a total of 15 children with autism (M age = 11.00 years, SD = 2.66 years) and 14 TD children (M age = 6.57 years, SD = 1.19 years) were included in data analysis. Detailed characteristics of the participants were summarized in **Table 1**. Despite careful matching, children with autism were significantly older ($p < 0.001$) but with lower scores on nonverbal IQ ($p < 0.001$) than TD peers.

Table 1. Demographic characteristics of participants.

Variable	ASD (n = 15)	TD (n = 14)	Group Difference
	M (SD)	M (SD)	*p*
Age (years)	11.00 (2.66)	6.57 (1.19)	<0.001
ESL (years)	1.14 (1.62)	0.61 (0.88)	0.683
Family SES	45.43 (16.86)	51.54 (6.56)	0.730
ADOS-2 Total Score[a]	8.42 (1.31)	-	-
Nonverbal IQ[b]	95.47 (18.54)	123.93 (13.87)	<0.001
Pretest			
Translation acc (%)	44.60 (20.90)	38.44 (13.97)	0.418
Identification acc (%)	51.75 (21.57)	44.56 (13.32)	0.325

Note: Group differences were assessed via nonparametric Mann-Whitney U tests. [a]ADOS-2 comparison severity score labels are as follow: 0–2 = "minimal-to-no evidence," 3–4 = "low," 5–7 = "moderate," 8–10 = "high." [b]Non-verbal IQ was measured by TONI-4 or PTONI (3 participants below 6-year-old).

2.2. Materials

The pretest was conducted at the 1st week to measure the baseline knowledge of the 48 words. The 48 target words were selected from standard English textbooks from Chinese primary schools to maximize ecological validity. The words were concrete, picturable object nouns drawn from categories familiar to children (e.g., animals, food, clothing, school supplies) and ranged from 1 to 3 syllables. Some words contained English phonemes absent from Mandarin (e.g., /θ/, /æ/, /v/) or consonant clusters; however, phonological features were not systematically manipulated as the study prioritized the use of words from textbooks. During the 8-week learning phase, participants learned 6 words per week and their learning data was recorded. Two tasks were designed and conducted immediately after each learning session and one week later. First, they completed a picture Identification task. The Identification task assessed receptive vocabulary knowledge, requiring participants to recognize a spoken English word and match it to the correct picture. Participants were asked to identify the object out of four choices with one correct answer and three distractors, including a semantically related object, a phonologically related object, and an unrelated object. Semantically related distractors were drawn from the same category as the target word (e.g., both animals). Phonologically related distractors shared onset or rhyme overlap with the target word's English form (e.g., onset: "cat"–"cup"; rhyme: "cat"–"hat"). However, not every test card contained all three distractor types, as suitable phonological or semantic foils were not available for all target words. Unrelated distractors had no semantic or phonological relationship with the target. All distractors were selected from a pool of common object pictures and reviewed by the research team for appropriateness. The position of the target object was counterbalanced. Then, they completed a Naming task which assessed expressive vocabulary knowledge, requiring phonological retrieval and production of the L2 form. In this task, they were asked to name objects in English. Testing materials in this task were colored pictures of the target words. Naming responses were scored live by the experimenter during the task. A response was scored as correct if it was judged to be a recognizable production of the target English word, with minor accent-related deviations accepted. Because responses were not audio-recorded, we were unable to calculate inter-rater reliability or conduct detailed phonological error analysis.

Two post-tests were designed to examine the overall learning outcomes at the 9th week and the 13th week. First, participants were asked to translate a target object from English to Chinese (Translation) without the presence of any object. The Translation task assessed cross-linguistic mapping between L2 forms and L1 equivalents, requiring participants to access the L1 equivalent upon hearing the L2 word. Then they were asked to identify the picture corresponding to the English name of that object (Identification) from a testing card. They were tested for 48 words individually in a randomized order. Accuracy rates were calculated as outcome measures.

2.3. Procedure

The current study was a longitudinal design lasting 13 weeks. It had 4 phases (see **Figure 1**), including a pretest (Week 1st before learning), a word learning phase (from Week 1st to Week 8th, 90 minutes per session), a post-test (Week 9th), and a follow-up post-test (Week 13th). The learning sessions were conducted in groups of 6–8 children. While this group size is smaller than a typical mainstream primary school class in China, it is comparable to class sizes in private English training centers. Each session lasted approximately 40 min, which is the standard lesson duration in Chinese primary schools, and was divided into two halves with a 10-min break in between. Similar to common pedagogical practices in L2 classrooms, we adopted a structured instructional routine that included whole-group teaching, individual practice, and interactive games. The instruction was delivered by a certified English teacher with two teaching assistants, using materials such as flashcards, picture cards, and songs, which are typical in early foreign language education.

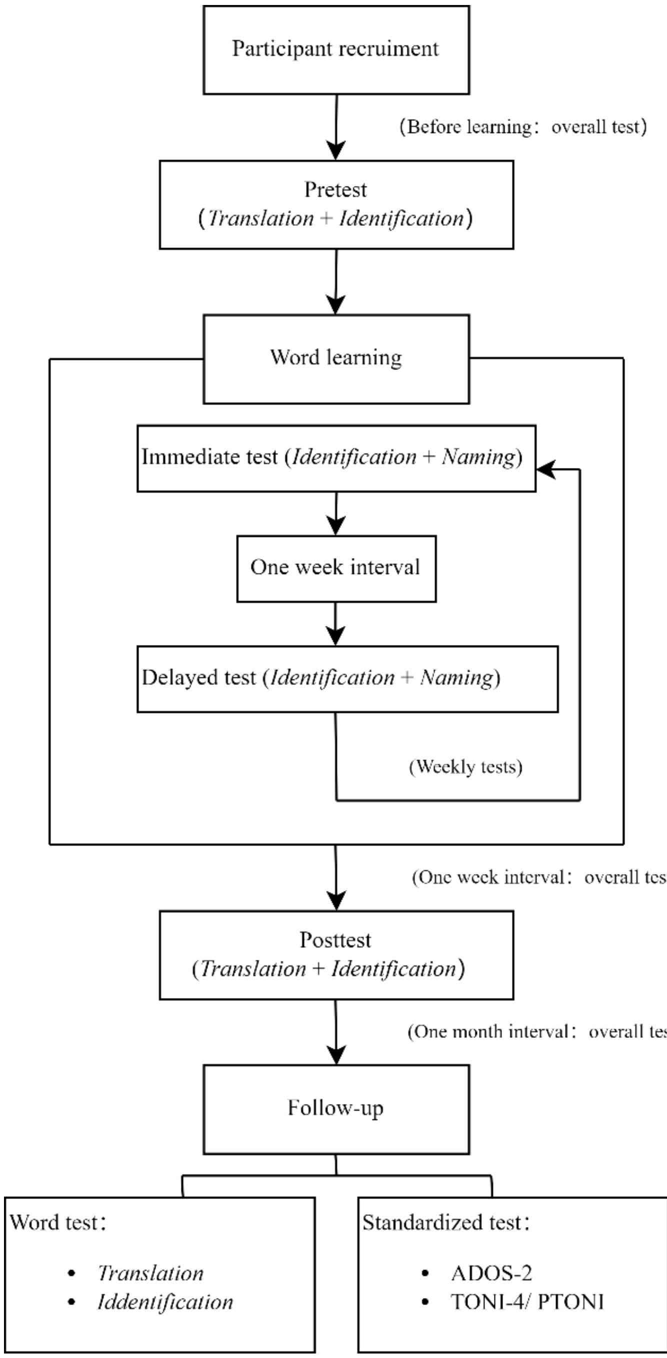

Figure 1. Experimental procedure illustrating the four main phases: Pretest, weekly learning with immediate and delayed tests, overall learning with posttest and follow-up.

This study began with a pretest in the first week to measure the baseline of participants' L2 vocabulary knowledge. The pretest employed two tasks: Translation and Identification. For the Translation task, participants were presented with the sound of target words in L2 (English) by the experimenter and were required to provide the corresponding translation in their L1 (Chinese). Then, for the Identification task, participants viewed a set of pictures (including images of the target item and three distractors) and were asked to identify the target object. Participants were tested for the whole list of words. Then, a two-month (one session per week with each session lasting 90 min) learning phase started. During this phase, participants learned 6 words per week in classroom-like settings. Each class had 6–8 students with an instructor and two teach assistants. To facilitate effective learning, instructional materials were carefully selected to provide scaffolding and cultivate interest. Target words were learned by presenting real objects, toy objects, jigsaw puzzle pieces, pictures, or stickers. These materials were integrated into games such as role-play and coloring activities, creating an interactive environment that facilitated active participant engagement. At the end of each learning session, accuracy rates for immediate Identification and Naming tests were calculated (Time 1: the immediate test), which required participants to identify and name the target words they had learned during the current session, respectively. Participants were also tested for their short-term retention using the Identification and Naming tasks of the target words learned during the previous session when the next session started (Time 2: the delayed test). At the 9th week and then the 13th test, Translation and Identification tasks used at the pretest were re-administered. The purpose of the post-tests was to measure the overall learning outcomes. Standardized tests were administered at the 13th week, including ADOS-2, TONI-4 or PTONI.

2.4. Data Processing

Nonparametric statistical methods were used for data processing given the modest sample size (N = 29) and because Shapiro-Wilk tests indicated non-normal distributions for several outcome variables. Nonparametric tests do not assume normality and are suggested for small samples [60]. First, Wilcoxon signed-rank tests were used to compare differences between accuracy rates at Time 1 (Immediate test) and Time 2 (Delayed test). Meanwhile, Wilcoxon rank-sum tests were applied to compare performances between children with autism and typically developing children. Then, the overall learning outcomes concerning L2 vocabulary growth and long-term retention were analyzed. Changes across the three time points (Pretest, Posttest, and Follow-up test) were examined using Friedman tests within each group, with post hoc comparisons conducted using Wilcoxon signed-rank tests with BH correction. Then, Wilcoxon rank-sum tests were conducted for between-group comparisons for each time point. Effect sizes were reported alongside all p-values (r for Wilcoxon and Mann-Whitney tests; Kendall's W for Friedman tests) to facilitate interpretation of practical significance. Finally, Spearman correlation analyses were conducted to explore the relationships between word learning outcomes (at first posttest and the follow-up test four weeks later) and several potential impact factors: (a) amount of English exposure, (b) family socioeconomic status, (c) autism severity (as measured by the ADOS-2), and (d) nonverbal IQ (as measured by the TONI-4 or PTONI). Supplementary partial Spearman correlations controlling for age and nonverbal IQ were also conducted for the key significant relationships and are also calculated and reported.

3. Results

3.1. Weekly Learning Outcomes

Figure 2 illustrates the average accuracy rates for the Identification and Naming tasks at Time 1 (Immediate test) and Time 2 (Delayed test). Wilcoxon signed-rank tests on participant-level averages (collapsed across the seven learning sessions) revealed no significant differences between Time 1 and Time 2 for either group. Children with autism showed comparable performance across time points for both Identification (V = 10, p = 0.590, r = 0.14) and Naming (V = 56, p = 0.484, r = 0.18). Typically developing (TD) children also showed no significant change for Identification (V = 24, p = 0.106, r = 0.43) or Naming (V = 24, p = 0.142, r = 0.39); the moderate effect sizes in the TD children suggest a possible trend toward improved delayed performance that may warrant investigation with larger samples. When comparing across tasks, both groups performed significantly better in Identification than in Naming. This receptive-expressive gap was robust for children with autism at both Time 1 (V = 91, p = 0.002, r = 0.81) and Time 2 (V = 91, p = 0.002, r = 0.81), and for typically developing children at Time 1 (V = 105, p = 0.001, r = 0.87) and Time 2 (V = 105, p = 0.001, r = 0.87). Between-group comparisons revealed no significant differences in Identification at either Time 1 (W = 85, p = 0.280, r = 0.20) or Time 2 (W = 92, p = 0.525, r = 0.12), or in Naming at Time 1 (W = 110, p = 0.861, r = 0.03) or Time 2 (W = 102, p = 0.913, r = 0.02). The negligible effect sizes for Naming indicate highly comparable expressive performance between groups.

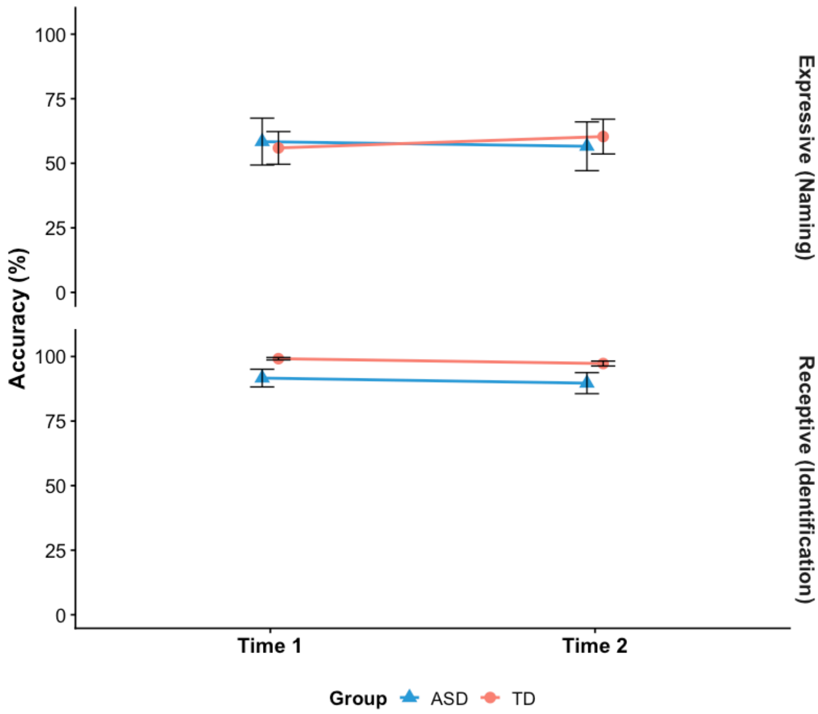

Figure 2. Weekly learning outcomes. Time 1 = Immediate Test. Time 2 = Delayed Test.

3.2. Overall Learning Outcomes

Table 2 presents the mean accuracy rates and standard deviations for Translation and Identification. Friedman tests revealed significant learning across the three time points for both groups (ASD Translation: $\chi^2(2) = 20.86$, $p < 0.001$, Kendall's W = 0.80; ASD Identification: $\chi^2(2) = 21.57$, $p < 0.001$, Kendall's W = 0.83; TD Translation: $\chi^2(2) = 23.10$, $p < 0.001$, Kendall's W = 0.83; TD Identification: $\chi^2(2) = 25.17$, $p < 0.001$, Kendall's W = 0.90). The large effect sizes (all Kendall's W > 0.80) indicate substantial vocabulary gains across the program. To examine performance at each timepoint, post hoc analyses were conducted separately within each group. Results are displayed in **Figure 3**.

Table 2. Performance in Translation and Identification tasks across time.

Task	Timepoint	ASD	TD	Friedman Test	Post hoc Comparisons: *p*, r Values			Between Group Comparisons: *p*, r Values
		M (SD)	M (SD)	χ^2 (*p*) [Kendall's W]	Pretest vs. Posttest	Pretest vs. Follow-Up	Posttest vs. Follow-Up	ASD vs. TD
Translation	Pretest	44.60 (20.90)	38.44 (13.97)	ASD: 20.86 (<0.000) [0.80]	ASD: 0.002, 0.82	ASD: <0.001, 0.87	ASD: 0.413, 0.21	-
	Posttest	82.23 (24.49)	82.65 (9.27)	TD: 23.10 (<0.000) [0.83]	TD: 0.001, 0.87	TD: 0.001, 0.88	TD: 630, 0.13	434, 0.15
	Follow-up	82.54 (17.76)	80.61 (12.90)					0.597, 0.10
Identification	Pretest	51.75 (21.57)	44.56 (13.32)	ASD: 21.57 (<0.000) [0.83]	ASD: 0.002, 0.81	ASD: <0.001, 0.87	ASD: 0.944, 0.02	-
	Posttest	89.38 (17.46)	94.73 (5.21)	TD: 25.17 (<0.000) [0.90]	TD: 0.001, 0.88	TD: 0.001, 0.88	TD: 0.086, 0.46	0.857, 0.03
	Follow-up	87.30 (17.56)	96.43 (3.82)					0.444, 0.14

For children with autism, post hoc Wilcoxon signed-rank tests revealed significant improvements from pretest to posttest in both Translation (Z = 3.16, $p = 0.002$, r = 0.82) and Identification (Z = 3.15, $p = 0.002$, r = 0.81). Significant gains were also observed from pretest to the follow-up test four weeks later (Translation: Z = 3.39, $p < 0.001$, r = 0.87; Identification: Z = 3.38, $p < 0.001$, r = 0.87). No significant differences were found between posttest and follow-up (Translation: Z = 0.82, $p = 0.413$, r = 0.21; Identification: Z = 0.07, $p = 0.944$, r = 0.02), indicating that learning gains were maintained over the four-week retention interval. For typically developing children, similar patterns emerged. Significant improvements were observed from pretest to posttest in Translation (Z = 3.27, $p = 0.001$, r = 0.87) and Identification (Z = 3.28, $p = 0.001$, r = 0.88), and from pretest to follow-up (Translation: Z = 3.27, $p = 0.001$, r = 0.88; Identification: Z = 3.27, $p = 0.001$, r = 0.88). No significant changes were found between posttest and follow-up for Translation (Z = 0.48, $p = 0.630$, r = 0.13) or Identification (Z = 1.72, $p = 0.086$, r = 0.46), indicating successful long-term retention. The moderate effect size for the TD Identification posttest-to-follow-up comparison (r = 0.46) suggests a slight numerical decline that did not reach significance.

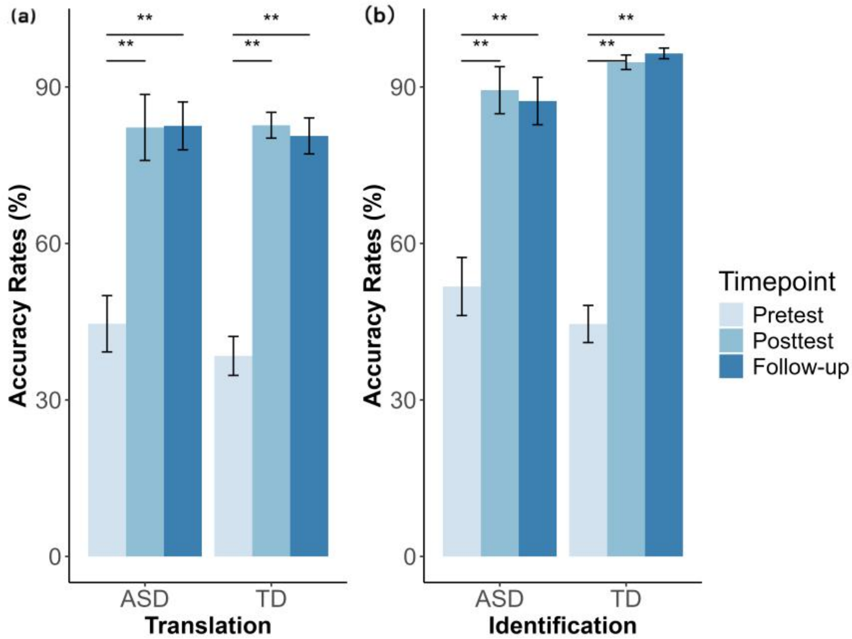

Figure 3. Overall learning outcomes for (**a**) Translation and (**b**) Identification.
Note: Error bars represent ±1 SE. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

Between-group comparisons using Mann-Whitney U tests revealed no significant differences between children with autism and typically developing children for Translation (posttest: W = 108, $p = 0.434$, r = 0.15; follow-up: W = 118, $p = 0.597$, r = 0.10) or Identification (posttest: W = 95, $p = 0.857$, r = 0.03; follow-up: W = 88, $p = 0.444$, r = 0.14). The consistently small effect sizes (all r ≤ 0.15) indicate comparable overall learning outcomes between groups at both time points.

3.3. Correlation Analysis

We conducted Spearman's correlation analyses to assess relationships between overall L2 learning outcomes (posttest and follow-up) and potential influencing factors, including English exposure (ESL), nonverbal IQ (TONI-4), family SES, and ASD severity (ADOS-2; children with autism only). Effect sizes (r) are reported alongside *p*-values (**Table 3**).

Table 3. Spearman correlation coefficients between overall learning outcomes and potential influencing factors.

Task	Variables	ASD Posttest	Follow-Up	TD Posttest	Follow-Up
Translation	1. ESL (years)	0.73**	0.66*	0.27	0.32
	2. Family SES	0.06	0.15	0.11	−0.11
	3. ADOS-2 Score	−0.14	−0.22	—	—
	4. Nonverbal IQ	0.5	0.62*	0.46	0.71**
Identification	1. ESL (years)	0.77**	0.58*	−0.07	0.18
	2. Family SES	0.12	0.09	0.42	0.23
	3. ADOS-2 Score	−0.33	−0.21	—	—
	4. Nonverbal IQ	0.45	0.56*	0.41	0.64*

Note: **p* < 0.05, ***p* < 0.01. Sample sizes vary from 12 to 15 due to missing data. ADOS-2 was administered to children with autism only.

For children with autism, English exposure was significantly positively correlated with Translation at posttest (r = 0.73, $p = 0.005$) and follow-up (r = 0.66, $p = 0.011$), and with Identification at posttest (r = 0.77, $p = 0.002$) and follow-up (r = 0.58, $p = 0.030$). Nonverbal IQ was significantly correlated with Translation at follow-up (r = 0.62, $p = 0.014$) and Identification at follow-up (r = 0.56, $p = 0.029$), but not with posttest performance (Translation: r = 0.50, $p = 0.083$; Identification: r = 0.45, $p = 0.125$). Neither ASD severity nor family SES was significantly correlated with any learning outcome (all $p > 0.29$). For typically developing children, English exposure was not significantly correlated with Translation (posttest: r = 0.27, $p = 0.358$; follow-up: r = 0.32, $p = 0.268$) or Identification (posttest: r = −0.07, $p = 0.801$; follow-up: r = 0.18, $p = 0.527$). Nonverbal IQ was significantly correlated with Translation at follow-up (r = 0.71, $p = 0.005$) and Identification at follow-up (r = 0.64, $p = 0.013$), but not with posttest performance (Translation: r = 0.46, $p = 0.100$; Identification: r = 0.41, $p = 0.149$). Family SES was not significantly correlated with any outcome (all $p > 0.14$).

Given the significant group differences in chronological age and nonverbal IQ, supplementary partial Spearman correlations were conducted to examine whether the key relationships held after controlling for these variables. Due to listwise deletion, the sample size was reduced (n = 13 for children with autism; n = 14 for typically developing children), and results should be interpreted with caution (**Table 4**).

Table 4. Partial Spearman correlation coefficients controlling for age and nonverbal IQ.

Task	Variables	Control	ASD		TD	
			Posttest	Follow-Up	Posttest	Follow-Up
Translation	1. ESL	Age + TONI	0.51	0.32	—	—
	2. Nonverbal IQ	Age	0.5	0.64*	0.46	0.60*
Identification	1. ESL	Age + TONI	0.64*	0.24	—	—
	2. Nonverbal IQ	Age	0.45	0.57	0.41	0.54

Note: *$p < 0.05$, **$p < 0.01$. Sample sizes vary from 12 to 15 due to missing data. ADOS-2 was administered to children with autism only.

For children with autism, after controlling for age and nonverbal IQ, the correlation between English exposure and Identification at posttest remained significant (r = 0.64, $p = 0.034$). However, the correlations between English exposure and Translation at posttest (r = 0.51, $p = 0.111$), Translation at follow-up (r = 0.32, $p = 0.339$), and Identification at follow-up (r = 0.24, $p = 0.474$) were attenuated and no longer significant. For the relationship between nonverbal IQ and learning outcomes, we controlled for age only. After controlling for age, nonverbal IQ remained significantly correlated with Translation at follow-up in children with autism (r = 0.64, $p = 0.026$) and in typically developing children (r = 0.60, $p = 0.029$). The correlations with Identification at follow-up approached significance in both children with autism (r = 0.57, $p = 0.052$) and typically developing children (r = 0.54, $p = 0.057$).

Taken together, the correlation analyses revealed that nonverbal IQ was linked to long-term retention across both groups while English exposure was selectively associated with learning outcomes in children with autism but not in typically developing children. The relationship between English exposure and learning in children with autism was partially attributable to shared variance with age and nonverbal IQ, though the association with Identification at posttest remained robust after controlling for these variables. In contrast, the relationship between nonverbal IQ and follow-up performance was largely independent of age in both groups. Family SES and ASD severity were not associated with any learning outcome, suggesting that within this structured instructional context, these factors did not substantially influence L2 vocabulary acquisition.

4. Discussion

This study investigated whether monolingual children with autism could learn and retain foreign language (L2) words in a classroom-like setting. We examined both immediate and long-term retention and explored potential factors influencing learning outcomes.

4.1. Weekly Learning and Retention

At the weekly level, both groups showed stable performance from immediate to delayed testing, with no significant differences between Time 1 and Time 2 for either Identification or Naming. This suggests that both children with autism and typically developing children were able to retain the words learned in each session over the one-week interval. The absence of significant within-group changes differs from some previous findings. For instance, Norbury et al. [51] reported that TD children showed sustained retention while children with autism exhibited a decline over time, and Henderson et al. [1] found that children with autism did not show the overnight lexical consolidation gains observed in TD children, a pattern linked to sleep-associated memory consolidation [52,53]. The discrepancy may reflect differences in task demands, instructional context, or measurement intervals across studies. In the present study, the structured, repetitive nature of the weekly sessions may have supported retention in both groups, reducing the consolidation gap. A robust receptive-expressive gap was observed across both groups, with significantly higher accuracy in Identification than in Naming at both time points. This is consistent with the well-documented receptive-expressive gap in L2 learners [61–63] and aligns with evidence that expressive tasks impose greater phonological retrieval demands [7]. Between-group comparisons revealed no significant differences in either Identification or Naming at the weekly level. The negligible effect sizes for Naming suggest comparable expressive performance between groups. This finding is somewhat unexpected given previous reports that children with autism often show less efficient lexical access and production [34,39,49]. However, given the modest sample size, these null findings should be interpreted with caution, as the study may have been underpowered to detect small-to-moderate effects.

4.2. Overall Learning Outcomes

Across the 8-week program, both groups showed significant overall improvement. Children with autism demonstrated gains from pretest to posttest in both Translation and Identification with large effect sizes, and these gains were maintained at the four-week follow-up. Typically developing children showed a parallel pattern of improvement and retention. No significant between-group differences emerged at posttest or follow-up for either task, and the effect sizes were consistently small (all $r \leq 0.15$). These findings offer preliminary evidence that, within a structured classroom-like context, children with autism may achieve L2 vocabulary learning outcomes comparable to their typically developing peers. This extends previous laboratory-based studies using novel word paradigms [1,50,51] to a more naturalistic group learning setting. The results also align with prior evidence challenging assumptions about bilingual limitations in autism [15,16,22,54] and are consistent with small-scale studies showing that children with autism can acquire L2 vocabulary [11,55,56]. However, replication with larger samples is needed to confirm these patterns.

4.3. Factors Influencing Learning Outcomes

Correlation analyses revealed some divergent patterns between groups, though these should be interpreted cautiously given the small sample and group differences in age and nonverbal IQ. English exposure was positively associated with learning outcomes in children with autism but showed no significant relationships in typically developing children. This pattern is consistent with previous findings that learners with autism may rely more on explicit, intentional learning than on incidental acquisition [64] and aligns with evidence that language exposure plays a significant role in L2 lexical development among individuals with autism [16,54]. It also resonates with reports that intensive linguistic interventions can facilitate vocabulary acquisition in this population [65]. However, partial correlation analyses indicated that some of these associations were attenuated after controlling for age and nonverbal IQ, with only the relationship between English exposure and Identification at posttest remaining significant. This highlights the difficulty of disentangling the effects of prior exposure from those of age and cognitive ability.

Nonverbal IQ was associated with long-term retention in both groups. After controlling for age, nonverbal IQ remained correlated with Translation at follow-up in both children with autism and typically developing children. This preliminary pattern suggests that domain-general cognitive resources may support long-term L2 vocabulary retention regardless of diagnostic status, consistent with evidence that cognitive ability contributes to language learning outcomes in autism [7, 34]. The finding that nonverbal IQ was broadly related to multiple tasks in children with autism rather than showing task-specific effects raises the possibility that learners with autism may draw on domain-general cognitive resources more broadly to support vocabulary acquisition [39]. Family SES and ASD severity were not associated with any learning outcome, but the small sample limits the conclusions that can be drawn.

Taken together, our findings provide preliminary evidence that children with autism may be capable of L2 vocabulary learning in a classroom-like setting, achieving outcomes broadly comparable to their typically developing peers over time. The selective association between English exposure and learning outcomes in children with autism suggests that structured, sustained instructional input may be particularly beneficial for this group, consistent with research highlighting the effectiveness of visually-supported, explicit instruction for learners with autism [30,49,66,67]. However, given the preliminary nature of these findings and the methodological limitations discussed below, these implications should not be overstated. Further research with larger, better-controlled designs is needed before drawing firm conclusions for educational practice.

4.4. Limitations and Future Directions

Several limitations should be noted. First, the ASD and TD groups differed significantly in chronological age and nonverbal IQ. Although supplementary partial correlation analyses were conducted, the modest sample size precluded formal covariate adjustment. These group differences may have influenced the learning outcomes, and the findings should therefore be interpreted with caution. Future studies should aim for closer group matching or employ larger samples that permit statistical control of these variables. Second, the overall sample size, while exceeding many existing studies in this area [11,55], remains modest. Participants learned in small groups rather than full-sized mainstream classrooms, limiting generalizability. Third, the exclusive focus on vocabulary acquisition leaves other critical linguistic domains unexplored [5,32]. Future studies should examine pronunciation, grammar, and conversational fluency. Fourth, the 13-week observation window, though longer than most prior investigations, may not fully capture long-term foreign language learning, and extended follow-up periods are warranted. Fifth, we did not collect direct measures of learning strategies or visual support utilization; future studies should incorporate such measures to directly test the hypothesis that structured, visually-supported instruction benefits learners with autism. Sixth, the absence of audio recording for the Naming task precluded detailed phonological analysis and inter-rater reliability assessment. Finally, the phonological characteristics of the target words were not systematically controlled, as the study prioritized ecological validity by mirroring a real textbook unit; future studies may benefit from systematic manipulation of phonological features to examine their impact on L2 word learning.

5. Conclusions

In summary, this study provides preliminary evidence that children with autism can learn and retain foreign language vocabulary in a classroom-like setting, achieving outcomes broadly comparable to their typically developing peers over time. While some of our weekly findings differed from prior reports of consolidation deficits in autism, the overall pattern of successful long-term learning is encouraging. English exposure was selectively associated with learning outcomes in children with autism, while nonverbal IQ was linked to long-term retention across both groups. These findings offer tentative support for the feasibility of inclusive L2 education for children with autism, though replication with larger, better-matched samples is essential before drawing strong conclusions or making educational recommendations.

Author Contributions

Conceptualization: X.K.; data curation: Y.Z., N.D., X.H., X.C., and Q.L.; data analysis: Y.Z. and X.K.; funding acquisition: X.K. and Y.Z.; investigation: Y.Z., N.D., X.H., X.C., and Q.L.; methodology: Y.Z.; project administration: Y.Z. and N.D.; resources: X.K.; visualization: Y.Z. and X.K.; writing—original draft: X.K. and Y.Z.; writing—review and editing: X.K., Y.Z., N.D., X.H., X.C., and Q.L. (based on CRediT: Contributor Roles Taxonomy, https://credit.niso.org/). All authors have agreed on the final completed version. We hold accountable for all aspects of the work to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding

This work was supported by National Social Science Fund of China [22CYY021], Natural Science Foundation Project of Chongqing, Chongqing Science and Technology Commission [CSTB2022NSCQ-MSX0494], the Fundamental Research Funds for the Central Universities [2022CDJSKPT26], and Graduate Scientific Research and Innovation Foundation of Chongqing, China [CYS240018].

Institutional Review Board Statement

The research protocol have been approved by the Ethics Committee of Chongqing Emergency Medical Center.

Informed Consent Statement

All caregivers of participants have provided written consent for their participation.

Data Availability Statement

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

Acknowledgments

All the participants and their caregivers, for their enthusiastic participation and invaluable support during the learning experiment and data collection.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research.

AI Use Statement

DeepSeek has been used for improving the English language. The authors subsequently reviewed and edited the content as necessary and take full responsibility for the final content of the published article.

References

1. Henderson, L.; Powell, A.; Gaskell, G.M.; et al. Learning and consolidation of new spoken words in autism spectrum disorder. *Dev. Sci.* **2014**, *17*, 858–871.
2. Larson, C.; Rivera-Figueroa, K.; Thomas, H.R.; et al. Structural language impairment in Autism Spectrum Disorder versus Loss of Autism Diagnosis: Behavioral and neural characteristics. *NeuroImage Clin.* **2022**, *34*, 103043.
3. Tager-Flusberg, H. Defining language impairments in a subgroup of children with autism spectrum disorder. *Sci. China Life Sci.* **2015**, *58*, 1044–1052.
4. Wittke, K.; Mastergeorge, A.M.; Ozonoff, S.; et al. Grammatical language impairment in autism spectrum disorder: Exploring language phenotypes beyond standardized testing. *Front. Psychol.* **2017**, *8*, 532.
5. Arunachalam, S.; Luyster, R.J. Lexical development in young children with autism spectrum disorder (ASD): How ASD may affect intake from the input. *J. Speech Lang. Hear. Res.* **2018**, *61*, 2659–2672.
6. Andreou, G.; Raxioni, K. Language development, reading and word learning in Autism Spectrum Disorder (ASD): A review on eye tracking studies. *Int. J. Dev. Disabil.* **2024**, *70*, 2–19.
7. Ferman, S. Morpholexical Processes in Children with Autism Spectrum Disorder: Evidence from Artificial Word Learning. *Folia Phoniatr. Logop.* **2021**, *73*, 248–262.
8. An, Z.G.; Hu, X.; Horn, E. Chinese inclusive education: The past, present, and future. *Interv. Sch. Clin.* **2018**, *54*, 118–122.
9. Li, M.; Lin, Y.; Bao, T.; et al. Inclusive education of elementary students with autism spectrum disorders in Shanghai, China: From the teachers' perspective. *BioScience Trends* **2022**, *16*, 142–150.
10. Zhou, H.; Xu, X.; Yan, W.; et al. Prevalence of autism spectrum disorder in China: A nationwide multi-center population-based study among children aged 6 to 12 years. *Neurosci. Bull.* **2020**, *36*, 961–971.
11. Hu, X.; Lee, G.T.; Pan, Q.; et al. Effects of foreign mand training on the emergence of foreign tact and listener responses for Chinese-speaking children with autism spectrum disorder. *Behav. Interv.* **2023**, *38*, 437–455.
12. Franco, M.; Costa, A.P. Should parents only use one language with their autistic children? The relations between multilingualism, children's social skills, and parent-child communication. *J. Autism Dev. Disord.* **2025**, *55*, 2761–2773.
13. Hudry, K.; Rumney, L.; Pitt, N.; et al. Interaction behaviors of bilingual parents with their young children with autism spectrum disorder. *J. Clin. Child Adolesc. Psychol.* **2018**, *47*, S321–S328.
14. Gilhuber, C.S.; Raulston, T.J.; Galley, K. Language and communication skills in multilingual children on the autism spectrum: A systematic review. *Autism* **2023**, *27*, 1516–1531.
15. Howard, K.B. Supporting learners with special educational needs and disabilities in the foreign languages classroom. *Support Learn.* **2023**, *38*, 154–161.
16. Phillips, S.; Yanchik, A.; Jung, H.; et al. Effects of bilingual language exposure on toddlers with autism spectrum disorder. *Front. Psychol.* **2024**, *15*, 1412339.
17. Yu, B. Issues in bilingualism and heritage language maintenance: Perspectives of minority-language mothers of children with autism spectrum disorders. *Am. J. Speech-Lang. Pathol.* **2013**, *22*, 10–24.
18. Beauchamp, M.L.; Rezzonico, S.; MacLeod, A.A. Bilingualism in school-aged children with ASD: A pilot study.

J. Autism Dev. Disord. **2020**, *50*, 4433–4448.
19. Drysdale, H.; van der Meer, L.; Kagohara, D. Children with autism spectrum disorder from bilingual families: A systematic review. *Rev. J. Autism Dev. Disord.* **2015**, *2*, 26–38.
20. Lund, S.; Rothwell, C.; Monaghan, P.; et al. A meta-analysis of word learning in autistic and neurotypical children: Distinguishing noun-referent mapping, retention, and generalisation. *Dev. Rev.* **2025**, *75*, 101171.
21. Ge, H.; Lee, A.K.L.; Yuen, H.K.; et al. Bilingual exposure might enhance L1 development in Cantonese-English bilingual children with autism: Evidence from the production of focus. *Autism* **2024**, *28*, 1795–1808.
22. Vulchanova, M.; Vulchanov, V.; Allen, M. Word learning in ASD: The sensorimotor, the perceptual and the symbolic. *J. Cult. Cogn. Sci.* **2023**, *7*, 9–22.
23. Dosi, I.; Sotiriadis, S. Interventions for early language development in monolingual and bilingual children with autism spectrum disorders: Two case studies. *Int. J. Res. Stud. Educ.* **2020**, *9*, 1–11.
24. Gonzalez-Barrero, A.M.; Nadig, A. Verbal fluency in bilingual children with Autism Spectrum Disorders. *Linguist. Approaches Biling.* **2017**, *7*, 460–475.
25. Peristeri, E.; Baldimtsi, E.; Andreou, M.; et al. The impact of bilingualism on the narrative ability and the executive functions of children with autism spectrum disorders. *J. Commun. Disord.* **2020**, *85*, 105999.
26. Peristeri, E.; Vogelzang, M.; Tsimpli, I.M.; et al. Bilingualism and second-order theory of mind development in children with autism over time: Longitudinal relations with language, executive functions, and intelligence. *Autism Res.* **2024**, *17*, 1818–1829.
27. Bialystok, E.; Craik, F.I.; Luk, G. Bilingualism: Consequences for mind and brain. *Trends Cogn. Sci.* **2012**, *16*, 240–250.
28. Bialystok, E. Bilingualism modifies cognition through adaptation, not transfer. *Trends Cogn. Sci.* **2024**, *28*, 987–997.
29. Davis, T.N.; Lancaster, H.S.; Camarata, S. Expressive and receptive vocabulary learning in children with diverse disability typologies. *Int. J. Dev. Disabil.* **2016**, *62*, 77–88.
30. Hashim, H.U.; Yunus, M.M.; Norman, H. 'AReal-Vocab': An augmented reality English vocabulary mobile application to cater to mild autism children in response towards sustainable education for children with disabilities. *Sustainability* **2022**, *14*, 4831.
31. Patael, S.; Diesendruck, G. Intentions help children learn meaningful rules. *J. Child Lang.* **2008**, *35*, 221–234.
32. Sukenik, N.; Tuller, L. Lexical semantic knowledge of children with ASD—A review study. *Rev. J. Autism Dev. Disord.* **2023**, *10*, 130–143.
33. Gladfelter, A.; Goffman, L. Semantic richness and word learning in children with autism spectrum disorder. *Dev. Sci.* **2018**, *21*, e12543.
34. Hartley, C.; Bird, L.A.; Monaghan, P. Investigating the relationship between fast mapping, retention, and generalization of words in children with autism spectrum disorder and typical development. *Cognition* **2019**, *187*, 126–138.
35. Jiménez, E.; Haebig, E.; Hills, T.T. Identifying areas of overlap and distinction in early lexical profiles of children with autism spectrum disorder, late talkers, and typical talkers. *J. Autism Dev. Disord.* **2021**, *51*, 3109–3125.
36. Mathée-Scott, J.; Larson, C.; Venker, C.; et al. Use of mutual exclusivity and its relationship to language ability in toddlers with autism spectrum disorder. *J. Autism Dev. Disord.* **2021**, *52*, 4528–4539.
37. Rothwell, C.; Westermann, G.; Hartley, C. How do autistic and neurotypical children's interests influence their accuracy during novel word learning? *J. Autism Dev. Disord.* **2024**, *54*, 3301–3315.
38. Luyster, R.; Lord, C. Word learning in children with autism spectrum disorders. *Dev. Psychol.* **2009**, *45*, 1774–1786.
39. Hartley, C.; Bird, L.A.; Monaghan, P. Comparing cross-situational word learning, retention, and generalisation in children with autism and typical development. *Cognition* **2020**, *200*, 104265.
40. Kover, S.T.; Ellis Weismer, S. Lexical characteristics of expressive vocabulary in toddlers with autism spectrum disorder. *J. Speech Lang. Hear. Res.* **2014**, *57*, 1428–1441.
41. Boucher, J. Research review: Structural language in autistic spectrum disorder—Characteristics and causes. *J. Child Psychol. Psychiatry* **2012**, *53*, 219–233.
42. Laudańska, Z.; van der Venne, P.; Preis, H.; et al. Communicative Development Inventories (CDIs) in etiologically diverse developmental conditions: A systematic review. *Res. Dev. Disabil.* **2026**, *170*, 105256.
43. Qian, L.; Shao, H.; Fang, H.; et al. Reliability, validity and developmental sensitivity of the Language Use Inventory (LUI) in the Chinese context. *Int. J. Lang. Commun. Disord.* **2022**, *57*, 497–511.
44. McGregor, K.K.; Berns, A.J.; Owen, A.J.; et al. Associations between syntax and the lexicon among children with or without ASD and language impairment. *J. Autism Dev. Disord.* **2012**, *42*, 35–47.

45. Perovic, A.; Modyanova, N.; Wexler, K. Comprehension of reflexive and personal pronouns in children with autism: A syntactic or pragmatic deficit? *Appl. Psycholinguist.* **2013**, *34*, 813–835.
46. Tager-Flusberg, H.; Caronna, E. Language disorders: Autism and other pervasive developmental disorders. *Pediatr. Clin. N. Am.* **2007**, *54*, 469–481.
47. Franken, T.E.; Lewis, C.; Malone, S.A. Brief report: Are children with autism proficient word learners? *J. Autism Dev. Disord.* **2010**, *40*, 255–259.
48. Tenenbaum, E.J.; Amso, D.; Abar, B.; et al. Attention and word learning in autistic, language delayed and typically developing children. *Front. Psychol.* **2014**, *5*, 490.
49. Harper-Hill, K.; Copland, D.; Arnott, W. Efficiency of lexical access in children with autism spectrum disorders: Does modality matter? *J. Autism Dev. Disord.* **2014**, *44*, 1819–1832.
50. Bosseler, A.; Massaro, D.W. Development and evaluation of a computer-animated tutor for vocabulary and language learning in children with autism. *J. Autism Dev. Disord.* **2003**, *33*, 653–672.
51. Norbury, C.F.; Griffiths, H.; Nation, K. Sound before meaning: Word learning in autistic disorders. *Neuropsychologia* **2010**, *48*, 4012–4019.
52. Davis, M.H.; Di Betta, A.M.; Macdonald, M.J.; et al. Learning and consolidation of novel spoken words. *J. Cogn. Neurosci.* **2009**, *21*, 803–820.
53. Dumay, N.; Gaskell, M.G. Sleep-associated changes in the mental representation of spoken words. *Psychol. Sci.* **2007**, *18*, 35–39.
54. Hambly, C.; Fombonne, E. Factors influencing bilingual expressive vocabulary size in children with autism spectrum disorders. *Res. Autism Spectr. Disord.* **2014**, *8*, 1079–1089.
55. Alemi, M.; Meghdari, A.; Basiri, N.M.; et al. The effect of applying humanoid robots as teacher assistants to help Iranian autistic pupils learn English as a foreign language. In Proceedings of the Social Robotics: 7th International Conference, ICSR 2015, Paris, France, 26–30 October 2015; pp. 1–10, 2015.
56. Zohoorian, Z.; Zeraatpishe, M.; Matin Sadr, N. Effectiveness of the picture exchange communication system in teaching English vocabulary in children with autism spectrum disorders: A single-subject study. *Cogent Educ.* **2021**, *8*, 1892995.
57. Lord, C.; Rutter, M.; DiLavore, P.C.; et al. *Autism Diagnostic Observation Schedule, Second Edition: ADOS-2*; Western Psychological Services: Torrance, CA, USA, 2012.
58. Brown, L.; Sherbenou, R.J.; Johnsen, S.K. *TONI-4, Test of Nonverbal Intelligence*; PRO-ED: Austin, TX, USA, 2010.
59. Ehrler, D.J.; McGhee, R.L. *Primary Test of Nonverbal Intelligence*; PRO-ED: Austin, TX, USA, 2008.
60. Siegel, S.; Castellan, N.J. *Nonparametric Statistics for the Behavioral Sciences*, 2nd ed.; McGraw-Hill: New York, NY, USA, 1988.
61. Gibson, T.A.; Oller, D.K.; Jarmulowicz, L.; et al. The receptive–expressive gap in the vocabulary of young second-language learners: Robustness and possible mechanisms. *Biling. Lang. Cogn.* **2012**, *15*, 102–116.
62. Keller, K.; Troesch, L.M.; Grob, A. A large receptive–expressive gap in bilingual children. *Front. Psychol.* **2015**, *6*, 1284.
63. Oller, D.K.; Pearson, B.Z.; Cobo-Lewis, A.B. Profile effects in early bilingual language and literacy. *Appl. Psycholinguist.* **2007**, *28*, 191–230.
64. Zwart, F.S.; Vissers, C.T.W.; van der Meij, R.; et al. Autism: Too eager to learn? Event related potential findings of increased dependency on intentional learning in a serial reaction time task. *Autism Res.* **2017**, *10*, 1533–1543.
65. Murdaugh, D.L.; Maximo, J.O.; Kana, R.K. Changes in intrinsic connectivity of the brain's reading network following intervention in children with autism. *Hum. Brain Mapp.* **2015**, *36*, 2965–2979.
66. Hartley, C.; Allen, M.L. Brief report: Generalisation of word–picture relations in children with autism and typically developing children. *J. Autism Dev. Disord.* **2014**, *44*, 2064–2071.
67. Skewes, J.C.; Kemp, T.; Paton, B.; et al. How are attention, learning, and social cognition related on the non-clinical autistic spectrum? *Acta Psychol.* **2020**, *210*, 103157.