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The semantic depth of Japanese-English bilingual children

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This study examined semantic organization in Japanese-English bilingual children, focusing on the syntagmatic-paradigmatic shift, cross-linguistic relationships between syntagmatic and paradigmatic associations, and the influence of lexical diversity on semantic organization. Participants were 30 Japanese-English bilingual children aged 2 to 8 ($M = 70.8$, $SD = 22.14$). A Word Association Task (WAT) assessed semantic knowledge in both languages, with responses coded for type, errors, and code switching. Lexical diversity (Number of different words) was measured using the Multilingual Assessment Instrument of Narratives (MAIN), and language input was measured using a questionnaire. Regression models revealed: No evidence of a syntagmatic-paradigmatic shift, but a gradual increase in both syntagmatic/paradigmatic responses with age and lexical diversity; and proficiency in generating paradigmatic and syntagmatic responses in one language predicted proficiency in the other, controlling for age and language input. This study highlights cross-linguistic influences in Japanese-English bilingual children's semantic organization, with implications for educators emphasizing the beneficial impact of language instruction in one language on the other.

KEYWORDS

bilingual, Japanese, paradigmatic, word association task, semantic depth, Multilingual Assessment Instrument of Narratives, heritage language

1 Introduction

The purpose of this study is to examine the depth of Japanese-English Bilingual children's lexical-semantic organization. In this study, lexical-semantic organization is defined by the breadth and depth of a child's vocabulary; breadth is the number of lexical entries in one's vocabulary (Sheng et al., 2013b), whereas depth is an understanding of the complex associations between words and how these words are organized into an efficient system (Sheng et al., 2013a, 2006). Additionally, bilingualism is defined using the definition from Kohnert et al. (2021, p. 10): a bilingual is determined functionally, or using a "needs-based perspective," such that, "individuals who have a past, present, or future need for two different languages are ... therefore considered bilingual." This study was done to bridge the gap in research on bilingual children's semantic development. Research on semantic development in bilingual children has been done in many languages and in many ways (e.g., Ameel et al., 2009; Weiss, 2020; Gathercole and Moawad, 2010; Jardak and Byers-Heinlein, 2017; Kan et al., 2024; Nelson, 1977; Peña et al., 2002, 2003; Sandgren et al., 2021; Sheng et al., 2006, 2012, 2013a,b; Viñas-Guasch et al., 2017). However, among the extant research, few studies have been done with Japanese-English bilingual children. This study offers a preliminary contribution to research on semantic development by examining an understudied population of bilinguals—Japanese-English bilingual children from preschool to school age. This study also has important implications for speech-language professionals and educators working with Japanese-English bilingual children. Vocabulary has been linked to academic success (Ricketts et al., 2007; Rohde and Thompson, 2007). Understanding the nuanced differences between the bilingual's vocabulary —both the breadth and depth—is vital for providing effective learning outcomes.

1.1 Bilingualism and semantic development

Bilingualism is a complex and dynamic system where the individual's two or more languages are simultaneously activated or inhibited (Abutalebi and Green, 2008; Costa et al., 2006), and language dominance can shift over a lifetime (Buac et al., 2014). Bilinguals may be simultaneous, acquiring two or more languages in the first 4 years of life (Genesee and Nicoladis, 2006), or sequential, learning an additional language later in life after acquiring their first language (L1). Despite extensive research on bilingual language acquisition, comprehensive models that fully capture bilingual cognition remain underdeveloped (Grosjean, 2006).

Bilingual semantic development follows similar foundational processes as monolingual acquisition, requiring children to segment speech streams, recognize words as arbitrary symbols, and map them onto concepts (Carey and Bartlett, 1978). Word learning relies on mental mechanisms such as inference, memory, phonological and syntactic awareness; by age four, monolingual English-speaking children have mastered most phonology and morphosyntax of their language (Bloom, 2002). Unlike monolingual children, however, bilingual children are required to navigate the presence of translation equivalents (i.e., words that share meaning across languages), which the mutual exclusivity assumption suggests could be problematic given that there almost necessarily be two words for every concept (Markman et al., 2003). However, some bilinguals begin using translation equivalents within their first year, indicating they may organize vocabulary by language rather than as a single system (Genesee and Nicoladis, 2006). Research showed that children also categorize words by semantic relations, which evolve through preschool and school-age (Capone and McGregor, 2005; Nelson and Nelson, 1990; Unger et al., 2016; Wojcik, 2018). For bilinguals, this process involves additional adaptation, as they navigate and interpret these semantic relationships within each language, accounting for cross-linguistic differences in meaning organization (Clark, 2017; Saji et al., 2008; Viñas-Guasch et al., 2017). According to the Competition Model, language users make use of differences in language cues to parse sentence constituents (Bates and Macwhinney, 1989). Speakers of different languages use different aspects of their language as cues to discern which part is the subject and which part is the object based on word order, animacy, and subject-verb agreement (Jarvis and Pavlenko, 2008, p. 98). When these surface cues are different, they make certain parts of the language more salient to the learner. Generally, adjective and verb mapping occurs at a later age than noun mapping (Arunachalam and Waxman, 2010), but Japanese, which allows the speaker to express a grammatical sentence with a verb alone (e.g., ikou [let's go]; tabete [please eat]; inai [they're not here]), or an adjective alone (e.g., takai [it's tall]; samui [it's cold]; yasukunai [it's not cheap]), increases the salience of these word classes. Tanouye (1979) observed that young Japanese children, 22 months to 28 months, produced many verb-only utterances, while Oshima-Takane (2006) states that balanced use of nouns and verbs appear typical, rather than the former appearing earlier. Thus, this surface cue in Japanese may help facilitate earlier acquisition of verbs. Language also guides the development of conceptual understanding of space, shape, and color (Clark, 2017) and being bilingual can even have impacts on cognition (Bialystok, 1999, 2001; Kormi-Nouri et al., 2003). These "impacts," coined "the bilingual advantage hypothesis," suggest that bilinguals have greater metalinguistic awareness, specifically on tasks that require high levels of control (Bialystok, 2001). Acquiring a second language adds additional complexity to an already complex process (i.e., acquiring one language), and there is evidence that shows that bilingualism may slow receptive vocabulary development (Bialystok et al., 2010). Despite this, recent research on bilingual language development has shown that bilingualism does not necessarily equate to reduced input in both languages (De Houwer, 2014), nor does bilingualism cause a language disorder, or even pose a disadvantage for typically developing children (Kohnert et al., 2021). Instead, experience with two languages will simply alter the "typical" language developmental trajectory.

One important difference between bilingual and monolingual language development is elucidated by the Revised Hierarchical Model (RHM; Kroll et al., 2010), which assumes a shared conceptual store across a bilingual's two languages, with the L1 (or the more comfortable language) having privileged access to the semantic system, and the L2 (or the less comfortable language) being mediated by the L1. This model suggests that learning a word in one language can support conceptual development in its translation equivalent via translation from the L2 to the L1. However, as children develop their language skills in their L2, they should develop similar semantic abilities across languages due to greater conceptual exposure, and mediation from the L1 will become less necessary. While the RHM was originally proposed for second language acquisition (SLA), it aligns with Cummins' Linguistic Interdependence Hypothesis (Cummins, 1979), which states that L2 competence depends on L1 competence. In semantic development, the L1—or the language through which a concept was learned—sets the stage for L2 development, requiring a certain level of L1 competence to reinforce L2 semantic knowledge. Several studies support these hypotheses (Ameel et al., 2009; Gathercole and Moawad, 2010; Jardak and Byers-Heinlein, 2017; Kan et al., 2024; Peña et al., 2002, 2003; Sheng et al., 2006, 2012, 2013a,b; Viñas-Guasch et al., 2017).

While research into bilingual children's semantic development has employed a variety of creative methods of teasing out the subtleties behind dual language acquisition, free association tasks have been paramount to this field of research (see Fitzpatrick and Thwaites, 2020; Nelson, 1977). The goal of much of the free association task research has been to properly describe the trends in the types of responses given. The syntagmatic-paradigmatic shift, described by Nelson (1977), is the shift in which monolingual English-speaking children—around 5–9 years old- transition from syntagmatic responses [e.g., thematic or function-based responses that are typically from a different word class (dog-fluffy)] to paradigmatic responses [e.g., categorical or taxonomic responses that are typically from the same word class (dog-animal)] as they refine their mental lexicon. Nelson emphasizes that this shift varies by word type, with nouns often eliciting paradigmatic responses at all ages, while adjectives and verbs show clearer developmental shifts. Nelson and Nelson (1990) provided supporting evidence for the shift, showing that monolingual 5-year-olds produced more slot-filler responses, whereas second graders produced more taxonomic responses. Francis (1972) explained this shift as a lengthy reorganization of how monolingual children isolate sentence constituents and compare related elements, which is important for facilitating productive language use. In a recent study, Wojcik and Kandhadai (2020) found that paradigmatic responses appear as early as 3 years old in monolinguals, but increase with age, while idiosyncratic responses decrease, and homogenous responses increase, providing evidence for increased communicative competence. Cronin (2002) emphasized that reading development plays a crucial role in facilitating the syntagmatic-paradigmatic shift, as children with stronger literacy skills transition to paradigmatic responses earlier. This is likely due to increased exposure to structured language and categorical word relationships in written text. Peña et al. (2002) found that Spanish-English bilingual children followed a similar trajectory, however, culture also influences free association responses. They found that responses for "birthday" differed by language—Spanish-speaking children listed "arroz" and "frijoles," while English-speaking children listed "hamburger" and "hotdogs." They suggested that language-specific scripts help organize vocabulary within a language, while taxonomic categories facilitate organization across languages. Sheng et al. (2006) used a repeated free association task and elicited three trials for each priming word; they found that the syntagmatic-paradigmatic shift in their Mandarin-English bilingual participants was largely unaffected by bilingualism, particularly when both language abilities were considered. While the syntagmatic-paradigmatic shift describes what kinds of concepts are activated, the spreading activation model (Collins and Loftus, 1975) provides a framework for how ideas are connected and activated in the mind. In response to a stimulus like "dog," activation spreads to related nodes, or concepts, like "pet," "animal," or "collie". Thus, retrieval of concepts related to the primed concept is quicker and easier. Sheng et al. (2012) found evidence supporting the spreading activation model. Specifically, children with an LI show fewer "strong" links in their semantic network compared to their TD peers. Later, Sheng et al. (2013b) found that bilinguals produced more paradigmatic responses in their dominant language, with older children more frequently code-switching into English when lacking vocabulary in Spanish, supporting the Linguistic Interdependence Hypothesis. Weiss (2020) studied Hebrew-English bilinguals and found that when Hebrew lexical retrieval was weaker, children relied more on surface-level morphological inflections. Lam et al. (2023) compared English monolinguals, Spanish-English bilinguals, and Mandarin-English bilinguals, finding a bilingual disadvantage in semantic convergence. Bilinguals' responses were less like adult norms, likely due to reduced language input, limiting exposure to language-specific lexical forms and word relationships. Kan et al. (2024) found that there was a positive correlation between paradigmatic responses in Cantonese and English during a free association task, suggesting a shared conceptual store and influence of heritage language on L2. Additionally, they did not find clear evidence for a syntagmatic-paradigmatic shift, as much of the free association research suggests. There are many ways to explain the patterns of responses given, and countless factors can affect how participants respond. More research using typologically complex language combinations and different age ranges would help to uncover some of the unknowns, and this study aims to do that.

1.2 The current study

This study examines the lexical-semantic organization of typically-developing Japanese-English bilingual children aged 2 to 8 years old. In particular, we focus on simultaneous bilinguals learning two typologically distinct languages: English as a majority language in school and Japanese as a heritage language at home and at Saturday school. Japanese is typologically distant from English, and semantically, words are organized and interrelated in vastly different ways than English (e.g., Brown and Gullberg, 2011; Kameyama, 1983; Saalbach and Imai, 2005). Japanese is an agglutinating language (Hasegawa, 2014, p. 3) with a subject-object-verb word order, and the interrogative word order does not differ from the declarative counterpart (Hasegawa, 2014, p. 3-4). Additionally, case particles are used to mark the syntactic or semantic relationship with the predicate (Hasegawa, 2014, p. 70). Finally, Japanese employs numeral classifiers to all nouns instead of using a plural form (Saalbach and Imai, 2005). Brown and Gullberg (2011) found a difference in how Japanese-English speaking adults perceive motion. Their data suggest that the acquisition of an L2 might be broadening how individuals construe motion. This is in line with the functional level of linguistic relativity, which states that using language in a particular way may influence thinking (Lucy, 1997) Thus, the typological and semantic differences between Japanese and English may have important implications for how Japanese-English bilinguals' semantic system develops compared to English. In addition to language differences, this bilingual group offers insight into semantic organization shifting from primarily phonological, to syntagmatic, to paradigmatic across the age range, and shifting language dominance with age due to English being the majority language. Kohnert et al. (2021, p. 101) notes that majority language skills typically see sharp gains, eventually surpassing the minority language. Thus, older children are expected to perform better in English tasks, while younger participants should show more balanced performance across languages. Previous studies have shown that semantic organization and convergence are essential factors in typical language development, and a lack of these factors are a sign of a language impairment (Peña et al., 2003; Sheng et al., 2012, 2013a). Building a more diverse body of research on semantic development in bilingual children has important implications for researchers, clinicians, and educators working with bilingual populations. There remains a need to investigate how specific language combinations and abilities across languages impacts semantic development from preschool through early school-age.

The current study is built from previous studies using a word association task (WAT) to assess the semantic development (e.g., Kan et al., 2024; Lam et al., 2023; Sheng et al., 2006). In the current study, Japanese-English children from a broader age-range were examined, including two- to eight-year-olds, which is similar to Wojcik and Kandhadai (2020). The WAT we used was a repeated, three-trial task, which is similar to Sheng et al. (2006). In addition, Kan et al. (2024) used a stimuli list that consisted of only nouns and found that the children had more syntagmatic responses in Cantonese than English but had a similar number of paradigmatic responses across languages. In this study, we included a variety of noun, verb, and adjective translation equivalents.

Specific research questions are:

1. In Japanese-English bilingual children (2 to 8 years old), is there a notable syntagmatic-paradigmatic shift in WAT responses around ages 5 to 8?
2. To what extent does lexical diversity (number of different words; NDW) predict within-language paradigmatic/syntagmatic responses, considering the influence of age and language input?
3. To what extent do cross-language paradigmatic/syntagmatic responses predict each other, considering the influence of age and language input?
4. To what extent does cross-linguistic lexical diversity contribute to Japanese-English bilingual children's paradigmatic and syntagmatic responses, beyond the effects of cross-language influences and within-language lexical diversity?

For question one, if Japanese-English bilingual children follow similar developmental patterns observed in monolinguals, older children should produce predominantly paradigmatic responses and younger children should produce predominantly syntagmatic responses (Nelson, 1977; Sheng et al., 2013a). To examine this shift, we employ two separate regression models: one with age as an independent variable and another with NDW as an independent variable. Age is included because the syntagmatic-paradigmatic shift typically occurs between ages 5 and 9 in monolinguals (Nelson, 1977). However, age alone is not always a reliable developmental indicator for bilinguals, as L1 proficiency can decline with reduced exposure and increasing reliance on L2 (Peña et al., 2002; Sheng et al., 2013a). A richer lexicon has been linked to stronger semantic networks and an increased ability to produce paradigmatic associations (Sheng et al., 2013a), aligning with the spreading activation model (Collins and Loftus, 1975).

For question two and four, we expect to see a positive association between paradigmatic/syntagmatic responses and lexical diversity both within and across languages. Not only will more lexical resources be available to the child, but from a spreading activation model, a richer vocabulary will allow for more activated concepts when one concept is primed (Collins and Loftus, 1975).

For question three, we hypothesize that based on Cummins' Linguistic interdependence hypothesis (Cummins, 1979), academically mediated language skills will be transferred across languages. Additionally, the RHM posits a shared conceptual store. Therefore, we anticipate seeing an association between the number of semantically related responses across each language (Kan et al., 2024; Ordóñez et al., 2002).

2 Materials and methods

2.1 Participants

Thirty typically-developing Japanese-English bilingual children participated in this study (17 boys, 13 girls) aged 2 to 8 ($M = 70.8$, $SD = 22.14$). This age range spans the period of substantial lexical reorganization, typically shifting from predominantly syntagmatic to paradigmatic responses around 5 to 9 years old, and predominantly unrelated or phonological responses before that (Nelson, 1977). Participants were recruited through convenience sampling methods. Twenty-seven of the participants attended the Japanese Academy of the Rockies (JAR), a Saturday-only school teaching typical school subjects in Japanese. The remaining three subjects were recruited through the parents of the 27 children who attended JAR. Apart from the two two-year-olds, all participants attended preschool or elementary school in English. Additionally, all participants had at least one Japanese-native parent and were considered simultaneous bilinguals (Genesee and Nicoladis, 2006). According to the caregiver questionnaires adapted from Cheung et al. (2018), most participants were more comfortable in English (23 children), while 4 children were more comfortable in Japanese, and 3 reported equal comfort in both languages. As a group, the participants were stronger in English than in Japanese at the time of testing. The majority of participants were born in the U.S. (24 out of 30) and had at least one Japanese-speaking parent, primarily mothers (29). Table 1 summarizes the language learning environment of the participants. Japanese-English input (JE input) was calculated by summing the total reported hours the child spent hearing each language, then turned into an ordinal scale. A "0" indicated the child's input was 0% Japanese and 100% English; a "10" indicated the child's input was 50% Japanese and 50% English; and a "20" indicated the child's input was 100% Japanese and 0% English. Their language environment showed a balanced mix of Japanese and English during structured activities (e.g., reading and dinner), but a stronger dominance of English during unstructured activities such as playing with friends and watching TV.

2.2 Materials

The Multilingual Assessment Instrument of Narratives (MAIN) was used to assess language ability and exposure, while a Word Association Task (WAT), adapted from Kan et al. (2024), measured semantic depth.

2.2.1 Multilingual assessment instrument of narratives

To elicit a language sample for a baseline understanding of the children's language abilities, the Multilingual Assessment Instrument of Narratives (MAIN Revised; Gagarina et al., 2019) was used as a story retelling task. The MAIN is a story with pictorial

TABLE 1 Participant demographic information and language input from the parent/caregiver questionnaire.

Demographic information	Total	
Age in years (*n*)	Two (2), Three (1), Four (8), Five (5), Six (3), Seven (6), Eight (5)	
Child born in the US	25 Yes, 5 no	
Japanese speaking parent(s)	29 Mothers, 2 Fathers	
Mother's education	2 Lower than HS, 2 GED/HS, 5 Associates, 10 Undergrad, 11 Postgrad	
Father's education	0 Lower than HS, 4 GED/HS, 4 Associates, 11 Undergrad, 11 Postgrad	
Language input while	**Mode weekly hours (*n*)**	**Mode language percentage (*n*)**
Reading aloud	0–5 and 6–10 (13)	50% Japanese 50% English (10)
Telling stories	0–5 (21)	40% Japanese 60% English (6)
Eating breakfast	0–5 (19)	20% Japanese 80% English (7)
Eating lunch	0–5 (22)	20% Japanese 80% English (9)
Eating dinner	6–10 (18)	50% Japanese 50% English (9)
Watching TV/videos	0–5 (11)	20% Japanese 80% English (9)
Playing word games	0–5 (25)	20% Japanese 80% English (10)
Playing with family	6–10 (9)	50% Japanese 50% English (7)
Playing with friends	0–5 (18)	100% English (14)
Japanese-English Weekly Input Score *(n)*		
4 (1), 5 (4), 6 (3), 7 (1), 8 (2), 9 (4), 10 (5), 11(4), 12 (1), 14 (1), 16 (2), 17 (2)		

Japanese-English Weekly Input Score was calculated by summing the total reported hours the child spent hearing each language, then turned into an ordinal scale. A "0" indicates the child's input was 0% Japanese and 100% English; a "10" indicates the child's input was 50% Japanese and 50% English; and a "20" indicates the child's input was 100% Japanese and 0% English. "n" represents the number of participants who had that distribution of input. For example, the first value "4 (1)" represents 20% of all input is in Japanese and 80% of all input is in English for 1 participant.

support that can be used as a story tell, retell, or model story. The dog and cat parallel stories were used in this study, and the order of administration was counterbalanced across participants. The English script was translated to Japanese with the help of a native Japanese speaker, following the standardized adaption process (Bohnacker and Gagarina, 2020) to ensure grammatical structure and story structure were consistent across languages. In this study, the story retelling task was used to elicit language samples, which provided us microstructural information, such as their mean length of utterances in morphemes (MLUm)—which is the average length of the child's utterances in morphemes—and NDW—which is the total unique words (not total words) the child used—in both Japanese and English. Children's narratives were recorded using OM System Olympus WS-882 Digital Voice Recorders and were transcribed and analyzed using Systematic Analysis of Language Transcripts (SALT) software (Version 20; Miller et al., 2019). The audio recordings in Japanese and English were transcribed by the PI and a trained Japanese-English bilingual research assistant (RA). The English story retells were transcribed and coded following SALT conventions. The English transcripts were coded to mark individual words and bound morphemes to calculate MLUm and NDW. For the Japanese language samples, we transcribed the samples by adapting the SALT transcription conventions with Hepburn romanization conventions (see Hasegawa, 2014, p. 55–57). Given that Japanese is an agglutinative language (Hasegawa, 2014, p. 3), indicating that units of meaning are added one after another, particularly with verbs, this made transcription and coding a difficult task. Aside from the potential form, past tense *ta-form*, and conjunctive *te-form*, which were left attached to the verb and indicated as a morpheme in SALT via forward slash, the auxiliary elements of the verbal complex were broken up into individual words with spaces in between (e.g., tabe tai, arui/te iru, or aru/ke/ta). This was done to increase Japanese NDW, which compared to English, is markedly lower due to the agglutinative morphology (see Appendix 1 for transcription examples). Two raters coded the transcripts and overlapped with five participants, yielding an interrater agreement of 99% for SALT coding. Table 2 summarizes participants' performance on the story retell task. Despite the MAIN being recommended for bilingual children ages 3 to 10, two participants in this study were two-year-olds (32 months and 2.87 MLUm; 33 months and 3.29 MLUm), and using the MAIN, their English MLUm aligned with the English-speaking children in Miller and Chapman (1981). Repeated measures ANOVA showed that children, on average, had stronger English skills than Japanese at the time of testing: MLUm, F (1, 29) = 31.90, $p < 0.001$, number of total words (NTW), F (1, 29) = 21.96, $p < 0.001$, and NDW, F (1, 29) = 19.15, $p < 0.001$. Japanese and English have vastly different morphosyntactic systems which makes it difficult to compare microstructure across the two languages, but this finding is consistent with the report from the caregiver questionnaires.

2.2.2 Word association task

A repeated word association task was used to examine children's semantic knowledge. The WAT was adapted from Kan et al. (2024), and included 20 words: 13 nouns, four adjectives, and three verbs (see Appendix 2). The verbs were presented in the bare infinitive form in English (e.g., "go" and "eat") and the basic or "dictionary form" in Japanese (e.g., "i-ku" and "tabe-ru") (Kaiser et al., 2013, p. 184). In Japanese, "adjectives proper" were presented in "-i" non-past form (e.g., "haya-i" and "atsu-i") (Kaiser et al., 2013, p. 151–152). Each child was tested separately in a quiet room in JAR. The WAT was conducted in two sessions, one in Japanese and one in English. The order of the languages was counterbalanced across participants. In each session, they were asked to generate three responses. The WAT responses were recorded using OM System Olympus WS-882 Digital Voice Recorders. The WAT responses in both Japanese and English were transcribed and each of the three trials were organized next to the priming word in a spreadsheet to be coded. Responses

TABLE 2 MAIN microstructural descriptive statistics.

Variable	Japanese			English			F
	M	*SD*	Range	*M*	*SD*	Range	*F(1,29)*
MLUm	5.11	1.73	1.55–8.11	6.92	2.09	2.76–12	30.25***
NDW	27.13	9.96	13–54	37.33	13.75	20–72	17.5***
NTW	53.23	27.07	15–131	80.33	35.12	39–154	18.58***

*** p <0.001.
MLUm; mean length of utterance in morphemes, NDW; number of different words, and NTW; number of total words from the language sample analysis.

were coded as error (and received a zero), syntagmatic (and received a one), or paradigmatic (and received a two). Error responses include nonsense or unrelated responses, phonological and rhymed responses, or if the participant responded, "I don't know." Syntagmatic responses include situational relations, such as actions [car-drive; kuruma-hashiru (car-drive)] or functions [money-buy; okane-kau (money-buy)], attributive relations watermelon-juicy; suika-oishii [watermelon-tasty]), or thematic relations (chopsticks-dinner; ohashi-yorugohan [chopsticks-dinner)] with the priming word (Nelson, 1977); syntagmatic responses are typically from a different word class, and they often modify the priming word. Paradigmatic responses included part-wholes [hand-finger; te-yubi (hand-finger)], synonyms [cold-chilly; samui-tsumetai (cold environment-cold thing)], antonyms and negations [tall-short; takai-hikui (tall-short); tall-not tall; neru-nenai (sleep-don't sleep)], coordinates [dog-cat; inu-neko (dog-cat), superordinates [watermelon-fruit; suika-kudamono (watermelon-fruit)], subordinates [dog-shiba inu; inu-shiba inu (dog-shiba inu)], and substance [chop sticks-wood; ohashi-ki (chopsticks-wood)] (Nelson, 1977). Code-switched responses were also noted, then coded the same as non-code-switched responses. Two raters each coded half of the WATs, with an additional overlap of five participants. Interrater agreement was 98.9% for WAT response coding.

2.3 General procedures

The children participated in the Japanese and English versions of the MAIN and WAT at least one week apart, with sometimes longer between sessions depending on the family's schedule, on Saturdays after school for the children who attended the Japanese Academy of the Rockies. For the children who did not attend the Japanese Academy of the Rockies, testing was done at least one week apart, with the day of the week being determined by the family's schedule. The order of language testing was counterbalanced. The examiners included three trained monolingual English-speaking RAs, the PI—who is a Japanese-English bilingual speaker—and a trained native Japanese-English bilingual RA. To create an environment conducive to the monolingual mode (Grosjean, 2006), the children were tested by a different examiner for both tests, and all interaction prior to the testing, and instructions given during the testing, were done strictly in the testing language. The MAIN was administered first. The participants were given the option of three stories in envelopes to choose from, however, each envelope contained the same story. This was to control for the effect of shared knowledge during the presentation of the pictures (Gagarina et al., 2019). After the child chose the envelope, the examiner would display the pictures while reading the story, then prompt the child to tell the story back, "in their own words." Following the story retell task, comprehension questions were asked about the story. Finally, the WAT was administered. The children were prompted with, "I am going to say a word, and you say three things that go with that word (in Japanese, "私は言を言いますので、それにする三つのを言ってください"). The examiner then gave a model trial, followed by one or two test trials with the child, depending on the child's understanding of the instructions. If the child was taking more than 5 seconds to come up with an answer, the prompt, "If you imagine X, what comes to mind?" (in Japanese, "Xを想像すると、何が思いつくの？"). After ample wait time was given, the examiner would move onto the next questions if the child did not respond. In addition to recording everything on a digital audio recorder, the WAT responses were written verbatim on a scoring form.

3 Data analysis

3.1 Preliminary analyses: correlations and developmental trends

Preliminary Pearson correlation analyses were conducted to explore trends between several variables (see Table 3). Japanese and English MLUm, Japanese and English NDW, Japanese-English weekly input (JE input), Japanese and English syntagmatic responses, and Japanese and English paradigmatic responses were used as variables. The correlation analyses results guided building the regression models. Of interest in our analyses were age and JE input, as they were identified as important factors influencing children's semantic development in previous studies (e.g., Duursma et al., 2007). The correlation analyses showed that JE input was not related to the other measures, however, children's chronological age (in month) was significantly correlated with all WAT responses. Thus, age and JE input were used as co-variates in all regression models.

Further analysis revealed that in Japanese, MLUm significantly increased with age ($\beta = 0.03$, $p < 0.05$) when controlling for JE input, while NDW showed a positive but non-significant relationship with age ($\beta = 0.140$, $p > 0.05$). In English, both MLUm ($\beta = 0.067$, $p < 0.001$) and NDW ($\beta = 0.45$, $p < 0.001$) significantly increased with age, even after accounting for JE input. The findings suggest that lexical diversity and utterance complexity

TABLE 3 Correlations between age, lexical diversity, and WAT responses.

Variables	1	2	3	4	5	6	7	8	9
1. Age (in month)	–	–	–	–	–	–	–	–	–
2. J MLUm	0.16*	–	–	–	–	–	–	–	–
3. E MLUm	0.46***	0.33**	–	–	–	–	–	–	–
4. J NDW	0.08	0.50**	0.17*	–	–	–	–	–	–
5. E NDW	0.47***	0.27**	0.39**	0.16*	–	–	–	–	–
6. JE Input	0.02	0.05	0.04	0.02	0.003	–	–	–	–
7. J Syn	0.21*	0.07	0.06	0.001	0.05	0.10	–	–	–
8. E Syn	0.27**	0.02	0.14*	0.09	0.08	0.001	0.35**	–	–
9. J Para	0.24**	0.06	0.28**	0.22**	0.24**	0.03	0.02	0.004	–
10. E Para	0.16*	0.001	0.16*	0.03	0.13*	0.12	0.001	0.02	0.64**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

J; Japanese, E; English, MLUm; mean length of utterance in morpheme, NDW; number of different words from the language sample analysis, JE Input = Weekly Japanese and English Input, Syn; syntagmatic, Para; paradigmatic.

TABLE 4 WAT responses descriptive statistics presented in M (SD).

WAT Response	Japanese				English				
	Trial 1	Trial 2	Trial 3	Total	Trial 1	Trial 2	Trial 3	Total	*F (1,29)*
Errors	3.03 (5.42)	4.27 (5.96)	6.53 (6.79)	13.83 (17.43)	3.03 (5.95)	3.77 (5.57)	5.90 (6.57)	12.70 (16.77)	0.22
Semantically correct	14.13 (6.87)	13 (6.95)	11.4 (7.46)	38.53 (20.55)	16.93 (5.94)	16.17 (5.65)	14.07 (6.64)	47.17 (16.94)	7.84**
Conceptually correct	16.97 (5.42)	15.73 (5.96)	13.43 (6.83)	46.13 (17.47)	16.97 (5.95)	16.23 (5.57)	14.10 (6.57)	47.30 (16.76)	0.23
Syntagmatic	10.40 (6.64)	9.17 (5.45)	8.43 (6.13)	28 (16.99)	12.57 (5.62)	11.13 (4.58)	9.87 (5.39)	33.57 (14.23)	4.53*
Paradigmatic	3.73 (4.02)	3.83 (3.14)	2.97 (2.85)	10.53 (9.37)	4.37 (3.76)	5.03 (3.76)	4.20 (4.23)	13.60 (11.13)	6.37*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$."Semantically Correct" is the sum of all syntagmatic and paradigmatic responses excluding code-switched responses. "Conceptually Correct" is the sum of all syntagmatic and paradigmatic responses including code-switched responses.

develop more robustly over time in English compared to Japanese, independent of input effects.

3.2 Regression models

Two separate multiple regression models were used to examine the presence of a syntagmatic-paradigmatic shift for Japanese and English. In all models, JE input was included as a covariate to control for variations in bilingual language exposure. The first regression model examined the total number of target responses (i.e., syntagmatic vs paradigmatic) as dependent variables, with age and response type (i.e., syntagmatic and paradigmatic) as independent variables. The model also included the interaction between age and response type. The second regression model followed the same structure but with lexical diversity (NDW) as the independent variable. The key focus of these models was on the age × response type interaction in the first model and the NDW × response type interaction in the second model, allowing us to determine whether the syntagmatic-paradigmatic shift was primarily driven by developmental age-related changes and/or by differences in lexical diversity.

Stepwise multiple regression models were conducted separately for Japanese and English paradigmatic and syntagmatic responses to examine the extent to which within-language lexical diversity (NDW) and cross-language word association responses predict bilingual children's word association patterns, while controlling for age and Japanese-English input. The dependent variables in the models were Japanese paradigmatic responses, Japanese syntagmatic responses, English paradigmatic responses, and English syntagmatic responses. Age and JE input were included as covariates in all models. Using Japanese paradigmatic responses as an example, the regression models with age and JE input to control for developmental and language exposure effects proceeded as follows: To address Research Question 2, Step 1 introduced Japanese NDW as an independent variable to determine whether within-language lexical diversity predicted Japanese paradigmatic responses. To address Research Question 3, Step 2 added English paradigmatic responses as an independent variable to test whether cross-language influences explained additional variance in Japanese paradigmatic responses. Finally, to address Research Question 4, Step 3 incorporated English NDW as an independent variable to assess whether lexical diversity in English contributed further explanatory power beyond cross-language effects.

4 Results

4.1 WAT performance

Table 4 summarizes the children's WAT responses. On average, participants produced a total of 10.53 paradigmatic responses (*SD* = 9.37) in Japanese and 13.6 (*SD* = 11.13) in English, whereas a total of 28 syntagmatic responses (*SD* = 16.99) in Japanese and 33.57 (*SD* = 14.23) in English. Repeated measures ANOVA showed that there was not a significant difference between total Japanese and English error responses, F (1, 29) = 0.22, $p > 0.05$. These results suggest the children had a similar number of errors in both languages. However, there was a significant difference between total Japanese and English syntagmatic responses, F (1, 29) = 4.53, $p < 0.05$, and paradigmatic responses, F (1, 29) = 6.37, $p < 0.05$, suggesting that they produced generally more syntagmatic and paradigmatic responses in English than in Japanese.

Consistent with Sheng et al. (2012), when the number of syntagmatic and paradigmatic responses was calculated from semantically correct responses (code-switched responses coded as errors), repeated measures ANOVA showed that there was a significant difference between the sum of both syntagmatic and paradigmatic responses together in Japanese and English, *LSM* = 38.53 and 47.17, respectively, F (1, 29) = 7.86, $p < 0.01$. However, when the number of syntagmatic and paradigmatic responses was calculated from conceptually correct responses (code-switched responses not coded as errors), there was no longer a significant difference between the sum of both syntagmatic and paradigmatic responses in Japanese and English, *LSM* = 46.13 and 47.3, respectively, F (1, 29) = 0.23, $p > 0.05$.

4.2 Syntagmatic-paradigmatic shift

Table 5 summarizes the results for both models. In Model 1, age was a significant predictor for both Japanese ($\beta = 0.30$, $SE = 0.07$, $t = 4.39$, $p < 0.001$) and English ($\beta = 0.26$, $SE = 0.05$, $t = 4.92$, $p < 0.001$), indicating that older children produced more responses overall compared to younger children. Additionally, children produced significantly more syntagmatic responses than paradigmatic responses in both Japanese ($\beta = -8.73$, $SE = 1.66$, $t = -5.25$, $p < 0.001$) and English ($\beta = -9.98$, $SE = 1.76$, $t = -5.69$, $p < 0.001$). However, the interaction between age and response type was not significant, indicating that there was no syntagmatic-paradigmatic shift (RQ1).

In Model 2, lexical diversity (NDW) significantly predicted paradigmatic responses in both Japanese ($\beta = 0.35$, $SE = 0.12$, $t = 2.73$, $p < 0.05$) and English ($\beta = 0.29$, $SE = 0.10$, $t = 2.89$, $p < 0.01$). Consistent with Model 1, children produced significantly more syntagmatic responses than paradigmatic responses in Japanese ($\beta = -8.73$, $SE = 1.69$, $t = -5.17$, $p < 0.001$) and English ($\beta = -9.98$, $SE = 1.78$, $t = -5.62$, $p < 0.001$). The interaction between NDW and response type was not significant, indicating that there was no syntagmatic-paradigmatic shift (RQ1).

Additional exploratory analyses were conducted to further examine patterns in lexical-semantic responses. First, analyses focused specifically on nouns, as Nelson (1977) proposed that an increase in paradigmatic responding would apply mostly to nouns. Thus, only the responses for the nouns were analyzed using the same stepwise models with similar findings: The interaction between age and response type was nonsignificant, and the interaction between NDW and response type was also nonsignificant, indicating that there was no syntagmatic shift seen specifically with nouns (see Table 6).

Second, the ratio of syntagmatic to paradigmatic responses was calculated for each child in each language, and the ratios

TABLE 5 Syntagmatic-paradigmatic shift: age and lexical diversity (NDW).

Variables	Japanese		English	
	β (SE)	*t*	*β (SE)*	*t*
Model 1				
Input (covariate)	0.73 (0.40)	1.79	−0.25 (0.31)	−0.79
Age	0.30 (0.07)	4.39***	0.26 (0.05)	4.92***
Response type	−8.73 (1.66)	−5.25***	−9.98 (1.76)	−5.69***
Age x response type	−0.07 (0.07)	−0.94	−0.07 (0.08)	−0.82
R^2	0.32		−0.10	
Model 2				
Input (covariate)	0.58 (0.47)	1.24	−0.38 (0.38)	−1.01
NDW	0.34 (0.12)	2.73*	0.29 (0.10)	2.89**
Response Type	−8.73 (1.69)	−5.17***	−9.98 (1.78)	−5.62***
NDW x Response Type	−0.00 (0.12)	−0.01	−0.02 (0.13)	−0.19
R^2	0.39		0.10	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
NDW; number of different words from the language sample analysis.

TABLE 6 Syntagmatic-paradigmatic shift based on noun task items only: age and lexical diversity (NDW).

Variables	Japanese		English	
	β (SE)	*t*	*β (SE)*	*t*
Model 1				
Input (covariate)	0.26 (0.24)	1.1	−0.19 (0.20)	−0.97
Age	0.16 (0.04)	4.01***	0.16 (0.03)	4.89***
Response type	−4.08 (1.27)	−3.21**	−4.52 (1.35)	−3.35**
Age x response type	−0.02 (0.06)	−0.29	−0.03 (0.06)	−0.42
R^2	−0.51		−1.27	
Model 2				
Input (covariate)	0.11 (0.30)	0.36	−0.28 (0.24)	−1.17
NDW	0.08 (0.11)	0.73	0.19 (0.06)	3**
Response type	−4.08 (1.19)	−3.42**	−4.52 (1.35)	−3.34**
NDW x response type	0.24 (0.12)	1.97	−0.03 (0.1)	−0.3
R^2	0.07		−0.76	

** $p < 0.01$, *** $p < 0.001$.
NDW; number of different words from the language sample analysis.

TABLE 7 Stepwise regression for Japanese and English paradigmatic responses.

Variables	Step 1 (model 1) β (SE)	Step 2 (model 2) β (SE)	Step 3 (model 3) β (SE)
Japanese paradigmatic responses			
Age (covariate)	0.15 (0.07)*	0.06 (0.05)	0.04 (0.06)
Input (covariate)	−0.47 (0.40)	0.09 (0.27)	0.09 (0.27)
Japanese NDW	0.37 (0.15)*	0.28 (0.10)**	0.26 (0.10)*
English Paradigmatic	–	0.59 (0.09)***	0.59 (0.10)***
English NDW	–	–	0.05 (0.10)
R^2	0.39	0.77	0.77
ΔR^2	–	0.30	0.0
English paradigmatic responses			
Age (covariate)	0.13 (0.12)	0.02 (0.08)	0.01 (0.08)
Input (covariate)	−0.89 (0.52)	−0.59 (0.35)	−0.46 (0.35)
English NDW	0.11 (0.19)	−0.07 (0.13)	−0.03 (0.13)
Japanese paradigmatic	–	0.94 (0.16)***	1.03 (0.17)***
Japanese NDW	–	–	−0.22 (0.15)
R^2	0.25	0.68	0.71
ΔR^2	–	0.43	0.03

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
NDW; number of different words from the language sample analysis.

TABLE 8 Stepwise regression for japanese and english syntagmatic responses.

Variables	Step 1 (model 1) β (SE)	Step 2 (model 2) β (SE)	Step 3 (model 3) β (SE)
Japanese syntagmatic responses			
Age (covariate)	0.45 (0.12)**	0.22 (0.16)	0.26 (0.19)
Input (covariate)	1.94 (0.72)*	1.56 (0.70)*	1.55 (0.71)*
Japanese NDW	−0.40 (0.28)	−0.01 (0.32)	0.03 (0.34)
English syntagmatic	–	0.52 (0.24)*	0.53 (0.25)*
English NDW	–	–	−0.11 (0.26)
R^2	0.40	0.49	0.50
ΔR^2	–	0.09	0.01
English syntagmatic responses			
Age (covariate)	0.39 (0.15)*	0.20 (0.16)	0.26 (0.14)
Input (covariate)	0.38 (0.65)	−0.34 (0.65)	0.15 (0.58)
English NDW	−0.11 (0.24)	−0.04 (0.22)	0.12 (0.19)
Japanese syntagmatic	–	0.41 (0.16)*	0.30 (0.14)*
Japanese NDW	–	–	−0.66 (0.21)**
R^2	0.28	0.43	0.60
ΔR^2	–	0.35	0.17

* $p < 0.05$, ** $p < 0.01$.
NDW; number of different words from the language sample analysis

for the preschool children (ages two to five) were compared to the school-age children (ages six to eight). Since error responses made up a larger portion of the younger children's responses than the older children's, a ratio provided a better means of comparing values of different sizes. While the ratio of syntagmatic to paradigmatic responses was lower in the school-age children, indicating a smaller difference between the two types of responses, there was a nonsignificant difference between the two groups for Japanese ($t = 0.47$) and English ($t = 0.31$).

Overall, older age and greater lexical diversity predicted a higher number of paradigmatic and syntagmatic responses. However, the results did not show evidence of a clear syntagmatic-paradigmatic shift in either Japanese or English.

4.3 Japanese paradigmatic responses

The upper portion of Table 7 presents the stepwise regression results for Japanese paradigmatic responses. In Step 1, Japanese NDW (JNDW) was included to assess the impact of within-language lexical diversity (RQ2), with age and input as covariates. JNDW emerged as a significant predictor of Japanese paradigmatic responses ($\beta = 0.37$, $SE = 0.15$, $p < 0.05$), indicating that greater lexical diversity in Japanese is associated with more paradigmatic responses. Age also showed a significant effect ($\beta = 0.15$, $SE = 0.07$, $p < 0.05$), whereas JE input was not significant.

In Step 2, English paradigmatic responses were introduced to examine cross-linguistic influences (RQ3). Both JNDW ($\beta =$ 0.28, $SE = 0.10$, $p < 0.05$) and English paradigmatic responses ($\beta = 0.59$, $SE = 0.09$ $p < 0.001$) were significant, contributing to a 30% increase in explained variance ($\Delta R^2 = 0.30$, $p < 0.001$). This suggests that bilingual children who demonstrate stronger paradigmatic associations in English and have greater lexical diversity in Japanese also exhibit enhanced paradigmatic responding in Japanese. Age was no longer significant, suggesting its effect was accounted for by these lexical predictors.

In Step 3, English NDW (ENDW) was added to explore the role of cross-language lexical diversity (RQ4). JNDW ($\beta = 0.26$, $SE =$ 0.10, $p < 0.05$) and English paradigmatic responses ($\beta = 0.59$, $SE = 0.10$, $p < 0.001$) remained significant, confirming their strong contribution to Japanese paradigmatic responses. However, ENDW was not significant ($\beta = 0.05$, $SE = 0.10$, $p > 0.05$), suggesting that lexical diversity in English does not play a role. Importantly, the explained variance did not increase from Step 2 to Step 3. The final model explained 77% of the variance ($R^2 = 0.77$).

4.4 English paradigmatic responses

The lower portion of Table 7 presents the stepwise regression results for English paradigmatic responses. In Step 1, English NDW was included to assess the impact of within-language lexical diversity (RQ2), with age and input as covariates. English NDW was a nonsignificant predictor of English paradigmatic responses ($\beta =$ 0.11, $SE = 0.19$, $p > 0.05$), indicating that greater lexical diversity in English is not associated with stronger paradigmatic responses. Neither age nor input were significant.

In Step 2, Japanese paradigmatic responses were introduced to examine cross-linguistic influences (RQ3). Japanese paradigmatic responses ($\beta = 0.94$, $SE = 0.16$, $p < 0.001$) was the only significant predictor, and ENDW remained nonsignificant ($\beta = -0.07$, $SE = 0.13$, $p > 0.05$), contributing to a 43% increase in explained variance ($\Delta R^2 = 0.43$, p < 0.001). This suggests that bilingual children who demonstrate stronger paradigmatic associations in Japanese also exhibit enhanced paradigmatic responses in English.

In Step 3, JNDW was added to explore the role of cross-language lexical diversity (RQ4). Japanese paradigmatic responses remained significant ($\beta = 1.03$, $SE = 0.17$, $p < 0.001$), while neither ENDW ($\beta = -0.03$, $SE = 0.13$, $p > 0.05$) nor JNDW ($\beta = -0.22$, $SE = 0.15$, $p > 0.05$) were significant. This final step contributed a 3% increase in explained variance ($\Delta R^2 = 0.03$), showing the importance of Japanese paradigmatic associations and their influence on English paradigmatic responses.

4.5 Japanese syntagmatic responses

The upper portion of Table 8 presents the stepwise regression results for Japanese syntagmatic responses. In Step 1, JNDW was included to assess the impact of within-language lexical diversity (RQ2), with age and input as covariates. JNDW emerged as a nonsignificant predictor of Japanese syntagmatic responses ($\beta = -0.40$, $SE = 0.28$, $p > 0.05$), indicating that greater lexical diversity in Japanese is not associated with stronger syntagmatic responses. Instead, age ($\beta = 0.45$, $SE = 0.12$, $p < 0.01$) and input ($\beta = 1.94$, $SE = 0.72$, $p < 0.05$) showed a significant effect.

In Step 2, English syntagmatic responses were introduced to examine cross-linguistic influences (RQ3). English syntagmatic responses ($\beta = 0.52$, $SE = 0.24$, $p < 0.05$) were a significant predictor, and JNDW remained nonsignificant ($\beta = -0.01$, $SE = 0.32$, $p > 0.05$), contributing to a 9% increase in explained variance ($\Delta R^2 = 0.09$). Input was also significant ($\beta = 1.56$, $SE = 0.70$, $p < 0.05$). This suggests that bilingual children who demonstrate stronger syntagmatic associations in English also exhibit enhanced syntagmatic responses in Japanese.

In Step 3, ENDW was added to explore the role of cross-language lexical diversity (RQ4). English syntagmatic responses ($\beta = 0.53$, $SE = 0.25$, $p < 0.001$) remained significant, confirming their contribution to Japanese syntagmatic responses. ENDW ($\beta = -0.11$, $SE = 0.26$, $p > 0.05$) and JNDW ($\beta = 0.03$, $SE = 0.34$, $p > 0.05$) were nonsignificant, but JE input was significant ($\beta = 1.55$, $SE = 0.71$, $p < 0.05$). This suggests that lexical diversity does not play a role in syntagmatic responses.

4.6 English syntagmatic responses

The lower portion of Table 8 present the stepwise regression results for English syntagmatic responses. In Step 1, English NDW was included to assess the impact of within-language lexical diversity (RQ2), with age and input as covariates. English NDW was a nonsignificant predictor of English syntagmatic responses ($\beta = -0.11$, $SE = 0.24$, $p > 0.05$), indicating that greater lexical diversity in English is not associated with stronger syntagmatic responding. Age was significant ($\beta = 0.39$, $SE = 0.15$, $p < 0.05$) but input was nonsignificant ($\beta = 0.38$, $SE = 0.65$, $p > 0.05$).

In Step 2, Japanese syntagmatic responses were introduced to examine cross-linguistic influences (RQ3). Japanese syntagmatic responses ($\beta = 0.41$, $SE = 0.16$, $p < 0.001$) was the only significant predictor, and ENDW remained nonsignificant ($\beta = -0.04$, $SE = 0.22$, $p > 0.05$), contributing to a 35% increase in explained variance ($\Delta R^2 = 0.35$, $p < 0.001$). This suggests that bilingual children who demonstrate stronger syntagmatic associations in Japanese also exhibit enhanced syntagmatic responses in English.

In Step 3, JNDW was added to explore the role of cross-language lexical diversity (RQ4). Japanese syntagmatic responses remained significant ($\beta = 0.30$, $SE = 0.14$, $p < 0.05$) and JNDW ($\beta = -0.66$, $SE = 0.21$, $p < 0.01$) was also significant, however, as a negative predictor. This final step contributed a 17% increase in explained variance ($\Delta R^2 = 0.17$, $p < 0.001$), showing the importance of Japanese syntagmatic associations together with Japanese lexical diversity and their influence on English syntagmatic responses.

5 Discussion

This study explores the depth of Japanese-English bilingual children's lexical-semantic organization, building on prior research on bilingual semantic development and cross-linguistic associations between typologically distinct languages (e.g., Kan et al., 2024; Sheng et al., 2013b). We recruited 30 typically developing Japanese-English bilingual children (17 boys, 13 girls) ages 2 to 8 ($M = 70.8$, $SD = 22.14$). A Word Association Task (WAT) in both languages assessed semantic depth. Key findings include: (1) Older children and children with greater lexical diversity produced more semantically related associations (syntagmatic and paradigmatic) than younger children, however, there was no shift from predominantly syntagmatic to predominantly paradigmatic associations (cf. Nelson, 1977); (2) English lexical diversity was not a significant predictor of WAT responses in either language, while Japanese lexical diversity was a significant positive predictor of Japanese paradigmatic responses and significant negative predictor of English syntagmatic responses; (3) strong cross-linguistic associations emerged, as syntagmatic/paradigmatic associations in one language invariably predicted those in the other.

5.1 Syntagmatic-paradigmatic shift

This study did not find any evidence of a shift from predominantly syntagmatic to predominantly paradigmatic responses. Rather, as the children got older, and as their lexical diversity increased, both their syntagmatic and paradigmatic responses increased, while their error responses decreased (see Figure 1). Across the age span, the children used significantly more syntagmatic responses than paradigmatic responses. However, there was no decrease in syntagmatic responses accompanied by (or caused by) an increase in paradigmatic responses. This finding

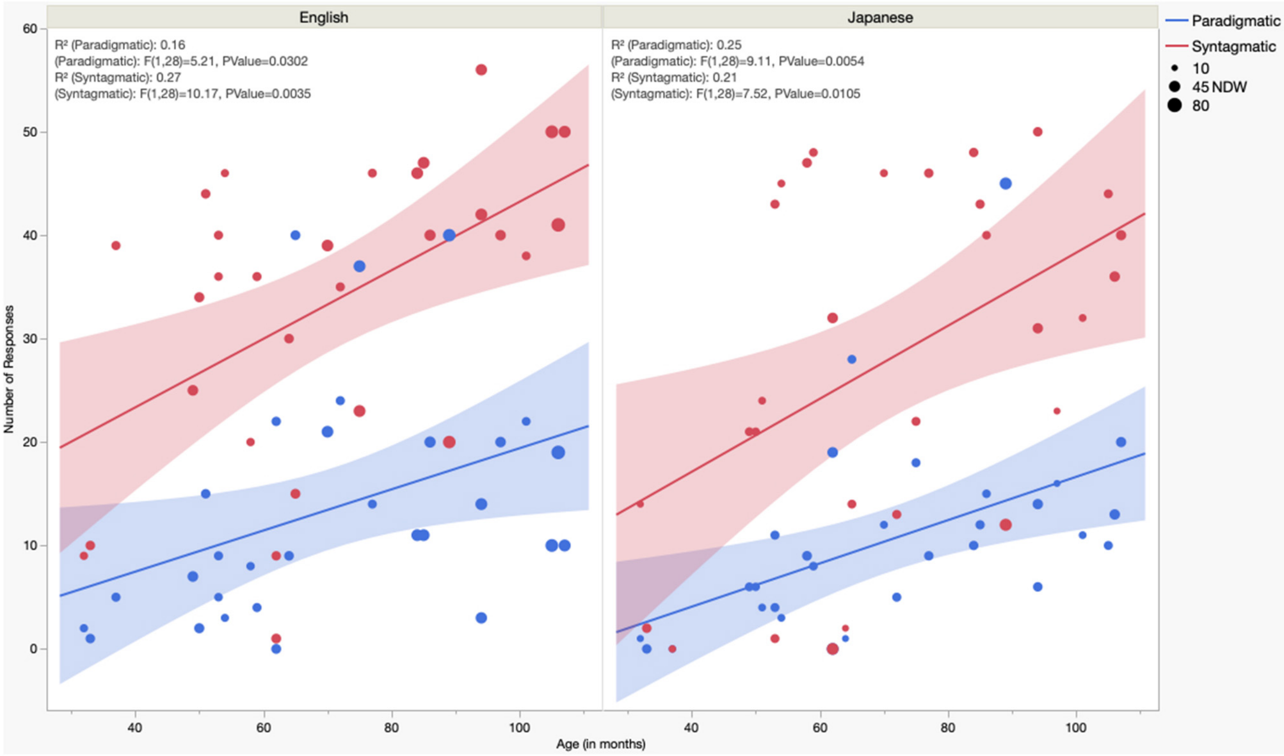

FIGURE 1
Graph of Number of paradigmatic/syntagmatic responses and NDW in each language plotted by age.

is different than the description given by Nelson (1977) in her review about the syntagmatic-paradigmatic shift: "Adults tend to give predominantly paradigmatic responses, whereas young children tend to give many syntagmatic responses, and a shift from younger to older response types seems to occur sometime within the 5 to 9 year-old age range." The children in the current study reduced the number of errors and phonological responses with age, giving room for gradually more syntagmatic and paradigmatic responses. Furthermore, even when the ratios of syntagmatic to paradigmatic responses were compared, there was no evidence of a shift.

One clear methodological explanation for the absence of a shift is the broad age range in our sample (ages two to eight), which may have introduced greater developmental variability. Our target sample size was informed by designs (i.e., Sheng et al., 2006) which successfully detected developmental trends using approximately 30 participants. However, previous studies examining more focused age groups, such as Sheng et al. (2006) (ages 5–8) and Kan et al. (2024) (ages 3–5), reported more distinct semantic patterns, with moderate to large effects observed within their more narrowly defined cohorts. In both studies, the age-related trends were more apparent, likely due to reduced variability and more developmentally homogeneous samples. To further contextualize our findings, a post hoc power analysis using G*Power (Faul et al., 2007) indicated that a within-subjects repeated-measures ANOVA (effect size $f = 0.25$, $\alpha = 0.05$, power $= 0.80$) would require 34 participants. A multiple regression model with five predictors ($f^2 = 0.5$) would require 32 participants. Our sample of 30 fell slightly below both thresholds. While comparable to the sample size used in Sheng et al. (2006), our broader developmental scope may have required a larger sample to detect more subtle age-related effects.

The absence of a syntagmatic-paradigmatic shift may reflect more than methodological limitations—it may also point to the differences in developmental trajectories among bilingual children. Our results diverged from Sheng et al. (2013a), who found that age alone was not a significant predictor of semantic performance, but age and language experience together contributed to greater semantic performance. In our study, both older age and greater lexical diversity independently predicted increases in syntagmatic and paradigmatic responses. This finding suggests that bilingual children's semantic development may follow a more distributed or additive trajectory, rather than a categorical shift. This corroborates Cummins' linguistic interdependence hypothesis (Cummins, 1979), which states that bilingual children can use their semantic knowledge in one language to leverage learning in the second language. Despite major microstructural differences and proficiency imbalances between the languages, syntagmatic/paradigmatic responses followed a gradual upward trend in both languages, consistent with the idea of a shared, underlying conceptual system.

Furthermore, the present results align with Cronin (2002), who found that paradigmatic responses became more frequent, syntagmatic responses remained constant, and inappropriate responses (errors) become less frequent, and Wojcik and Kandhadai (2020), who found that paradigmatic responses appear as early as 3 years old in monolinguals but increase with age. The current study saw a continued increase in syntagmatic and paradigmatic responses, while inappropriate responses decreased with age and lexical diversity. Taken together, these patterns reflect a developmental broadening and strengthening of lexical-semantic networks, even in the absence of a discrete syntagmatic-paradigmatic shift.

5.2 WAT responses

5.2.1 Paradigmatic associations

The current study found a consistent cross-linguistic association in paradigmatic associations, as measured by the WAT. The number of paradigmatic associations in one language significantly correlated with those in the other and increased with age. Japanese lexical diversity partially predicted Japanese paradigmatic responses, but English lexical diversity did not predict English paradigmatic responses. The youngest participants (32 months) produced three paradigmatic associations across both languages, aligning with Wojcik and Kandhadai (2020), who found paradigmatic associations as early as 3 years old. This study extends that finding to two-year-olds. Nelson (1977) noted that the syntagmatic-paradigmatic shift is most evident in high-frequency adjectives, while nouns show paradigmatic associations earlier, and verbs exhibit syntagmatic associations later. Similarly, two-year-olds in this study primarily produced paradigmatic associations with noun priming words, with two instances involving adjectives. Many of these associations were likely learned in school, such as "head, shoulders, and knees" in response to "ear."

These findings align with Kan et al. (2024), who found cross-linguistic WAT paradigmatic associations in Cantonese-English bilingual preschoolers, and support the RHM (Kroll et al., 2010), which posits a shared conceptual store across languages. They also reinforce Cummins' Developmental Interdependence Hypothesis (Cummins, 1979), which states that L2 competence is influenced by L1 development. Since the participants were typically developing and lived in a primarily English-speaking community, their Japanese proficiency likely depended in part on their English development. Lastly, consistent with Sheng et al. (2013b), who found language experience predicted paradigmatic responses, children in this study produced more paradigmatic responses in English than Japanese, reflecting their greater English exposure (five days a week in English public school vs. one day a week in Japanese school).

5.2.2 Syntagmatic associations

The current study also found a consistent cross-linguistic association in syntagmatic associations, as measured by the WAT. The number of syntagmatic associations produced in one language significantly correlated with those in the other. Moreover, syntagmatic associations increased with age: the youngest participants (32 and 33 months old) averaged 17.5 syntagmatic responses across both languages, while the oldest (8-year-olds) averaged 78.8. Notably, three children responded to the priming word "象" ("elephant") with the phrase "鼻がい" ("the nose is long"), famously introduced in the Japanese grammar book "像は鼻がい" by Mikami (1960), illustrating their grasp of Japanese grammar. This finding parallels Peña et al. (2002), who observed similar language-specific associations ("scripts").

In contrast, Ordóñez et al. (2002) found that the relationship between Spanish-English bilingual children's communicative skills (syntagmatic associations) in Spanish and English was evident only when Spanish and English breadth of vocabulary knowledge were controlled. Our study, however, revealed that the number of syntagmatic responses in one language significantly predicted those in the other, despite vocabulary knowledge. This difference may be influenced by task differences. Unlike Ordóñez et al. (2002), who sought full definitions, our WAT elicited single-word responses, which does not tax morphosyntactic knowledge to the same extent. Additionally, similar to Sheng et al. (2013a), as the children in our study got older, they tended to employ more translation equivalents (i.e., same response in both languages), which may explain this difference in findings – were the children in the current study required to give phrasal or sentential responses, lexical diversity may have had a greater influence.

An interesting finding in our study was the negative association between Japanese lexical diversity and English syntagmatic responses. Preliminary Pearson correlations found that Japanese NDW was not correlated with age, Japanese syntagmatic, or English syntagmatic responses (see Table 3). This is consistent with the research regarding bilingual vocabulary distribution being unbalanced compared to monolinguals (e.g., Bialystok et al., 2010; Ohana and Armon-Lotem, 2023). Given that English is the community language and the more comfortable language for most of the children in our study, it is possible that most of them have gaps in their Japanese vocabulary, which may explain this finding. Another explanation might be that those who are exposed to less Japanese input—and have a smaller Japanese NDW—are consequently exposed to more English input, which may equate greater English grammar (syntagmatic) knowledge. In other words, less Japanese experience allows for more English experience. Cummins (1979) posited that conceptual knowledge (paradigmatic associations) will easily transfer across languages, given that the L1 is adequately developed, whereas surface structures of language (syntagmatic associations) require explicit instruction. Therefore, the current study found that while paradigmatic associations easily transfer across languages regardless of lexical diversity or input in the other language, syntagmatic associations are impacted by lexical diversity or input in the other language. Considering the spreading activation model, greater lexical diversity in Japanese allowed for more paradigmatic concepts to be activated in Japanese. However, this greater Japanese lexical diversity may have had non-facilitative effects on English syntagmatic conceptual activation. Greater Japanese lexical diversity is likely a result of greater Japanese input, but since syntagmatic knowledge does not easily transfer across languages, the children were not able to leverage their Japanese lexicon to support their English syntagmatic knowledge activation.

5.3 Limitations and future directions

Despite the significant patterns revealed through the regression analyses, several methodological limitations should be noted. The small sample size and broad age range in the present study might have introduced developmental variability that limited our ability to detect more fine-grained age-related trends. A larger sample would enhance statistical power, while a narrower age range would enable more detailed observations of developmental changes in Japanese-English bilingual children's lexical-semantic organization. Additionally, this study relied solely on an expressive task (WAT) to examine semantic development. Incorporating receptive measures, such as the word association identification task used in Kan et al. (2024), could have strengthened the findings. Furthermore, the MAIN elicited an average of only 12.83 utterances in English and 12.24 in Japanese, which is significantly fewer than recommended in the literature (Heilmann et al., 2010). Future research should address these limitations by increasing the sample size, narrowing the age range, incorporating additional tasks such as a receptive measure, and increasing the participants' language sample size. Finally, these findings require replication with a more diverse sample of Japanese-English bilinguals, or other language combinations with Japanese (e.g., Japanese-Dutch, Japanese-Portuguese, etc.) to fully understand how Japanese interacts with a second language during the developmental period.

5.4 Clinical implications

This study has important clinical implications for educators and speech-language pathologists (SLPs) working with Japanese-English bilingual children. First, cross-linguistic influence should be considered—enhancing vocabulary depth in one language can lead to gains in the other. This is an important finding because bilingual SLPs and educators are not always available. Second, SLPs should strengthen lexical-semantic organization by explicitly teaching both syntagmatic and paradigmatic relationships. Nelson (1977) noted that paradigmatic relationships are typically learned in school, contributing to the syntagmatic-paradigmatic shift, thus, higher levels of schooling correlate with stronger semantic organization. Additionally, dictionaries define words using both paradigmatic substitutional equivalence theories of meaning (i.e., meaning through synonyms, paraphrases, or translations) and syntagmatic contextual theories of meaning (i.e., meaning based on syntactic relationships) (Noth, 1995). Definitions rely on paradigmatic associations, while example sentences reflect syntagmatic associations. This implication is important because developing deep syntactic and semantic knowledge helps the child learn new words, make connections between words and concepts, make logical inferences about how unknown words are related to known words, and how new words fit into the syntax of their language(s). Thus, it is important for children to develop both types of associations for truly robust lexical-semantic knowledge. While no standardized assessments test for specifically the knowledge of syntagmatic or paradigmatic associations specifically, subtests from the Comprehensive Assessment of Spoken Language—Second edition (CASL-2; Carrow-Woolfolk, 2017) such as "Antonyms," "Synonyms," and "Meaning from Context" can all assess a child's lexical semantic knowledge, and provide the educator with valuable information about the child's understanding of the connections between words and any difficulties the child may be experiencing. Through explicit instruction in semantic relationships, SLPs and educators can help improve Japanese-English children's semantic breadth and depth.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Institutional Review Board (IRB) at CU Boulder. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

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Appendices

Appendix 1

Japanese Utterance SALT Transcription Examples

- Soshite aru toki inu ga nezumi wo tori *taka/tta* kedo.
  Then at one point the dog *want/ed* to catch the mouse.

- Fukuro to fuusen wo *mo/tte* i ∧mashi/ta.
  (He) was (∧polite/past tense) *holding/conjunctive form* a bag and a balloon.

- Soshite inu ga ki ni butsuka/tte.
  Then the dog bumped/conjunctive form into the tree.

- Soshite ki ni hikkaka ∧ccha/tte.
  Then (it) got caught (∧*accidentally/conjunctive form)* in the tree

- Mi ∧naka/tta *kedo*.
  (He) ∧didn't/past tense see *but*...
- Hito wa kidzui/te *i* ∧mase/n ∗deshi/ta.
  The person *did* ∧polite/not (∗polite/past) notice/conjuctive form.

- Tsukamae *you* ∧to shi/te.
  (He) *tried* (∧conditional) to catch (it).

- Soshite koko kara de/te *ki/te*.
  Then (he) came/conjunctive form *out/conjunctive form* from here.

- Kanashi *sou* ∧de.
  (He) *looks* sad (∧conjunctive form).

- Shounen ga booru wo mizu kara to/re/ta.
  The young boy get/was able to/past tense the ball from the water.

Appendix 2

English and Japanese WAT priming words

1. Watermelon; スイカ
2. Apple; りんご
3. Eye; 目
4. Chopsticks; お箸
5. Fish; 魚
6. Tall; たかい
7. Pillow; まくら
8. Sleep; 寝る
9. Go; 行く
10. Mouth; 口
11. Hand; あつい
12. Hand; 手
13. Cold; さむい
14. Eat; 食べる
15. Dog; 犬
16. Elephant; ぞう
17. Money; お金
18. Ear; 耳
19. Car; 車
20. Fast; はやい