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"Simpler is better": Japanese children's learning of case-markers in transitive sentences

Zhao Zhao Akiko[a,b], Hiromu Sakai[c], and Yingyi Luo[d]

[a]Japan Society of the Promotion of Science, Keio University, Tokyo, Japan; [b]Faculty of Environment and Information Studies, Keio University, Kanagawa, Japan; [c]Center for English Language Education, Faculty of Science and Engineering, Waseda University, Tokyo, Japan; [d]Institute of Linguistics, Chinese Academy of Social Sciences, Beijing, China

ABSTRACT

Using the artificial language paradigm and the scenario-pointing task, the present study explored the case-marker learning of Japanese-speaking children and examined the qualitative and quantitative factors that may influence this cognitive development. In Experiment 1, participants aged five to seven years, but not those aged four years, steadily learned the novel markers for subject – object identification with simple argument-omitted sentences. However, the benefit of learning with full-argument sentences was unclear. In Experiment 2, seven-year-olds, who showed agent-first bias, were specifically studied with their artificial marker input quantitatively manipulated. The omitted and full sentences comprised 100%-0, 80%-20%, 20%-80%, and 0–100% of the four groups. The results suggested a robust case-marker learning effect even when the omitted sentences were the less probable structures in the input; such an effect was lacking, however, if only full-argument sentences were provided in the learning phase. Thus, we concluded that simple structures lead to greater benefit for case-marker learning and proposed that ages 5 and 7 may serve as developmental milestones for Japanese-speaking children in acquiring the various types of linguistic knowledge necessary for the development of the case system.

Introduction

The agent–patient distinction of the case system is fundamental in linguistic accounts of the semantic units that underlie language processing (e.g., Fillmore, 1968); it provides the basic "who-did-what-to-whom" structure of the utterance (Tomasello, 2003, p. 139). For example, in the English sentence, "A girl pushed a boy," the agent is "a girl," and the patient is "a boy," which is syntactically indicated through word order. In languages such as English and Chinese, word order distinguishes the agent and patient by marking the subject and the object in transitive sentences. In addition to word order, case-markers are important cues in some languages for indicating argument roles for the nouns of subjects and objects in transitive sentences, particularly in rich case-marked languages in which an SOV structure is possible (Subject-Object-Verb), such as Japanese, German and Korean (e.g., Bates & MacWhinney, 1989; Göksun et al., 2008; Lindner, 2003). This study focuses on children's learning of case-markers in Japanese, a verb-final language in which the omission of arguments (null-subject and/or null-object) is very common.

Examples of Japanese transitive sentences with non-SOV structures are presented below.

CONTACT Yingyi Luo luoyingyi@cass.org.cn Institute of Linguistics, Chinese Academy of Social Sciences, Beijing, China
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(1) otokonoko wo onnanoko ga oshita
boy-ACC girl-NOM pushed "*A girl pushed a boy*"
(2) onnanoko ga oshita
girl-NOM pushed "*A girl pushed*"
(3) otokonoko wo oshita
boy-ACC pushed "*A boy was pushed*"

In example sentence (1), the "boy" marked by a following object (accusative) case-marker *wo* is an object, and the "girl" marked by the following subject (nominative) case-marker *ga* is a subject despite the word order (e.g., Shibatani, 1990). While example (1) is a full-argument sentence with both case-markers, (2) takes only a subject marked by *ga*, with the object omitted, and (3) takes only an object marked by *wo*, with the subject omitted. Therefore, Japanese-speaking children cannot fully comprehend argument roles in sentences until they have acquired the case-markers *ga* and *wo* (e.g., Hakuta, 1982).

Developmental evidence from different languages has shown that most children utilize word order as a productive syntactic device for marking agents and patients (subjects and objects) from an early age (e.g., Japanese: 3y, Hayashibe, 1975; German: 5y; Dittmar et al., 2008; English: 2y; Dittmar et al., 2011), and this knowledge is gradually mastered as an abstracted rule as experience in lexical use accumulates. However, the milestone age for acquiring case-markers seems to be delayed to five or even as late as seven (Dittmar et al., 2008; Hayashibe, 1975; Lindner, 2003; Suzuki, 2007), suggesting that the learning of case-markers is more difficult than the learning of word order (e.g., Dittmar et al., 2008; Suzuki, 2007).

A question of case-marker learning thus arises: among the variety of linguistic inputs that children receive, what context effectively helps them abstract the symbolic usage of case-markers, and what context may not help? In the following, we review the cross-linguistic literature on children's development of case-markers, specifically highlighting the potential role of word order knowledge in this course. Then, we clarify the challenge of learning Japanese case-markers in view of the frameworks highlighting different weights of cues in sentence comprehension, e.g., the competition model (Bates & MacWhinney, 1989). Third, we discuss exposure complexity and amount, factors that are considered detrimental to language learning, and propose how they may contribute to children learning case-markers in different types of languages.

Development of case-markers across languages

In his influential work, Slobin (1973) proposed that there are four stages of linguistic marking of a semantic notion that are typically observed: (1) no marking, (2) appropriate marking in limited cases, (3) overgeneralizing case-marking (often accompanied by redundant marking), and (4) a full adult system. Cross-linguistic observations have shown that the acquisition of case-markers takes several years (Eisenbeiss et al., 2008), even after case-markers emerge in children's spontaneous speech in languages that rely heavily on case-markers (e.g., German: Mills, 1985; Japanese: Clancy, 1985; Korean: Kim, 1997). For example, Kim (1997) reported that both nominative and accusative markers emerge at approximately two years of age in the spontaneous speech of Korean-speaking children. However, the children had difficulties comprehending case-markers in sentences with atypical word order (i.e., OSV: Object-Subject–Verb) without context up to age five, as experimental studies reported (e.g., Song et al., 1997). In addition, before the age of four, Korean-speaking children mistakenly applied the nominative marker "ka" to nouns requiring the accusative marker "lul," indicating the underdevelopment of marking objects and the overgeneralization of marking subjects (Kim, 1997).

German-speaking children begin to use case-markers to mark the subject and object in a sentence at approximately three years of age in their spontaneous speech; however, they have the experience of unproductive, rote-learned and contextually restricted application and overgeneralization of case-markers (Clancy, 1985; Kim, 1997; Mills, 1985). Only when children reach six to seven years of age can they utilize case-markers to comprehend transitive sentences; before that, they use word order instead, resulting in the misunderstanding of scrambled sentences such as “Den Hund bafft der Elefant (The masculine-accusative dog is amazed by the masculine-nominative elephant).” Therefore, it is considered that children, on average, would not have truly mastered German case-markers to identify agents and patients by the age of seven (Dittmar et al., 2008; Lindner, 2003).

Japanese-speaking children begin to use the object case-marker “wo” in spontaneous speech when they are approximately two years old, as shown in example (4). However, at this age, children also mistakenly use “ga” to express an object, as illustrated in (5). This indicates that the use of case-markers is not grammatically generalized but rather lexically dependent, suggesting that “ga” is learned in association with specific nouns rather than as a general rule (e.g., Yokoyama, 1990). This reflects the co-occurrence of specific words and markers in children’s experiences (e.g., Clancy, 1985; Slobin, 1973).

(4) okane wo motte tta (2;0) (CHILDES, Miyata corpus)
money-ACC bring-PAST “*(Somebody) took the money (to somewhere)*”
(5) omizu *ga (wo) ireta (2;1) (Clancy, 1985)
water-*NOM (ACC) put “*(I) put water (in the cup)*”

In a study with a comprehension task (Suzuki, 2007), Japanese-speaking monolingual children aged three to five years performed a forced-choice discrimination of scenarios by listening to twenty sentences with a single argument (10 of “Subject-*ga* + Verb” and 10 of “Object-*wo* + Verb”). The results indicated that the subject marker *ga* is typically acquired at four years old with an accuracy of 90%, whereas *wo* is acquired later at five years old. Another study examining Japanese children’s comprehension of two-argument structured sentences also supported the claim that five-year-olds have acquired both markers (Hayashibe, 1975). In this study, children listened to SOV and OSV sentences with both markers and then used two puppets to act out the events described by the sentences. The children aged three and four years performed correctly for SOV but not for OSV sentences, implying that they relied on canonical word order rather than case-markers to parse the sentence with two arguments. After turning five, they showed no difficulty in comprehending both structures.

Nevertheless, recent studies have questioned whether word order cues are persistently used by young Japanese children in comprehending the “N-N-V” structure because monolingual participants aged 2–5 years did not show a preference to interpret the first-mentioned noun as the subject (i.e., agent bias; Segalowitz, 1982) in Japanese sentences without case-markers (Zhao, 2022). Interestingly, when identical sentences were given, such an interpretation preference was strong among 6- to 10-year-old bilinguals living in Japan.[1] The author considered that the difference between the two groups may be attributed to L1-to-L2 influences. The evidence presented here indicates that the acquisition of case-markers and knowledge of word order may interact during children’s language development, which emphasizes the need to incorporate the role of word order into any explanation of case-marker learning.

Cue validity of case markers in sentence comprehension

Within a language, cues used for the case system differ in their contributions to sentence comprehension, i.e., the validity of certain cues relative to the others, as postulated in the competition model (Bates & MacWhinney, 1989). For example, English prioritizes canonical word order (SVO), whereas German and Japanese speakers prioritize case markers for actor assignment in the adult language (Bates & MacWhinney, 1989; see also Tomasello, 2003), indicating a typological difference. Empirical studies further quantify these indices (Dittmar et al., 2008). Dittmar et al. (2008) analyzed the use of case markers and word order in transitive sentences in a German CDS corpus (i.e., CHILDES) including six German-speaking children who were 1.8 years old and 2.5 years old. They reported

[1]Their mother tongue was Chinese (11 participants), Indonesian (2), Vietnamese (1) and Nepalese (1).

that the availability and reliability, i.e., how often the cue was present when it was needed and how often the cue led to the correct interpretation of sentences, respectively, were relatively high for both cues (Study 1). However, the unambiguous markers *der* for the subject and *den* for the object appeared in only 21% of all transitive sentences, possibly resulting in children up to 7 years of age being unable to fully understand transitive sentences with these markers in the absence of canonical word order (Studies 2 and 3).

According to these definitions, case-markers are also relatively weakly available in Japanese. However, the attribution is different from that in German. In Dittmar et al. (2008), only 13% of the sentences involved either subject or object ellipsis, and these sentences were excluded from the analysis. In Japanese, omissions of arguments and case-markers commonly occur and are particularly salient in CDS (Ikeda et al., 2016; Matsuo et al., 2012). For example, Matsuo et al. (2012) analyzed a larger corpus of natural interactions between children aged 1;10 to 2;2 years and caregivers (i.e., the Jun corpus from the CHILDES database; Ishii, 1999; MacWhinney, 2000). Among the transitive sentences uttered by caregivers, 16.2% had both arguments, while 1.3% took both *ga* and *wo* as well; 4.5% carried only overt subjects (i.e., object-omitted), in which the subject case-marker *ga* presented a proportion of approximately one-third (1.5% of the total). A total of 63.3% of all sentences had only overt objects (i.e., subject-omitted), but only 5% used *wo* to mark the objects. In other words, children are exposed to an enormous number of sentences with omissions or with other markers that take up functions other than indicating the argument structure (e.g., the topic markers *mo* or *wa* or the dative marker *ni*). Even more disturbing is the fact that full-argument sentences are sometimes marked by *ga* (subject-marker) and *ga* (object-marker) (e.g., *kuma-ga mizu-ga nomitai* "bear-NOM water-ACC drink-want-PRES") (3.6%). Following Dittmar et al. (2008), Table 1 shows the cue validity by case-markers and by word order in Japanese Table 1 and German Table 1 based on the data of Matsuo et al. (2012) and Dittmar et al. (2008).

As is clearly shown in Table 1, on the one hand, the cue availability of subject and object case-markers is far lower in Japanese CDS than in German CDS. On the other hand, while the subject-first order is predominantly used in German CDS, the OV order accounts for more than half of the transitive sentences in Japanese CDS, which raises questions about the predominant order and the development of agent bias for Japanese children.[2] This calls for an explanation of what mechanism may underlie children's learning of linguistic facilities (e.g., case-markers) that neither occur with high probability nor are often surrounded by rich linguistic information (e.g., sentences with full-arguments).

The impact of linguistic information richness and distributional language learning

Equipped with knowledge about world events, children appear to be capable of creating semantic structures and utilizing them to learn new words such as verbs, nouns and prepositions (Arunachalam & Waxman, 2010, 2011, 2015; Ferguson et al., 2018; Fisher et al., 2006; He & Arunachalam, 2017; Imai et al., 2005; Syrett et al., 2014). Experimental studies have shown that children around two years of age are able to determine how many and what types of participant roles a verb involves in acquiring the meaning of a new verb (Arunachalam & Waxman, 2015). A similar learning mechanism has been observed in function word learning (Fisher et al., 2006; Landau & Stecker, 1990). In Fisher et al. (2006), the experimenter placed an object on one corner of a box and uttered two types of sentences involving a new string: "This is a corp" and "This is acorp my box." English-speaking 2-year-olds who heard the former interpreted the new word "(a)corp" as a category name for an object (i.e., a noun), and those who heard the latter interpreted it as a spatial relational term meaning "on" (i.e., a preposition). This result suggests that children at this age are able to acquire prepositions by understanding the scenario and by using their preexisting syntactic knowledge of such a sentence frame, e.g., a preposition should

[2]In fact, it is widely acknowledged that Japanese is a context-dependent or high-context language (e.g., Hall, 1976; Takai & Ota, 1994). Native speakers produce and comprehend sentences that lack syntactic and semantic components, heavily relying on situational information (Takai & Ota, 1994).

Table 1. (a) Cue availability in the Japanese case system. (b) Cue availability in the German case system.

(a) Japanese	availability (%)	(b) German	availability (%)
ga (used in transitive sentences)	2.8	Der	8
wo (used in transitive sentences)	6.3	Den	13
Subject-first transitive sentence (SOV, SV)	20.5	Subject-first sentence	79
SV	4.5	Object-first sentence	21
SV (no marker)	1	One-argument sentence	13
S-ga-V	1.5		
other (S-mo-V)	2		
SOV	16.2		
SOV (no case-marker)	11		
S-ga-O-V	0.1		
S-O-wo-V	0.2		
S-ga-O-wo-V	1.3		
other (S-ga-Oga-V)	3.6		
Object-first transitive sentence (OV)	63.3		
OV (no marker)	56		
O-wo-V	5		
O-ga-V	0.3		
other (O-wa/mo/ni-V)	2		
Verb-only sentence (V)	16		

precede the noun "my box" in the latter, confirming the important role of rich event and syntactic knowledge in learning linguistic novelty.

However, the opposite was observed in languages where sentence frames are often simple and arguments are regularly omitted. Sentences with sparse, rather than rich, linguistic information (e.g., argument-omitted sentences) make it easier for children to learn new words (e.g., Arunachalam et al., 2013; Imai et al., 2005). In Imai et al. (2005), English-speaking five-year-olds were found to acquire the novel verb (e.g., "X") more effectively in the full-argument sentence context (e.g., "She is X-ing it") than in the argument-omitted sentence context (e.g., "X-ing" with the subject and object dropped). In contrast, Japanese-speaking individuals of the same age comprehended action meaning more accurately when the novel verb (e.g., "neket") was presented in an argument-omitted sentence (e.g., "neket-teiru: verb-progressive") than when it was presented in sentences with both the subject and the object (e.g., "Oneesan *ga* nanika *wo* X-teiru (X-progressive):" girl-NOM something-ACC verb-progressive). A similar tendency was observed for verb learning in Korean-speaking children (Arunachalam et al., 2013). These findings indicate that the role of the information richness of the syntactic context in learning linguistic novelty is language type-specific rather than language-universal. Japanese and Korean children's verb learning has been described as "the simpler the better" rather than "the richer the better." Imai et al. (2005) proposed that the ineffectiveness of full-argument sentences was due to Japanese children's infrequent encounters with this type of sentence so that they tended to utilize the more frequent and familiar structure and achieve better learning performance with that structure.

On the other hand, while it has been widely acknowledged that children are generally sensitive to the probabilistic cues of linguistic input and tend to acquire frequent forms more readily than infrequent forms, researchers have focused on exploring the conditions under which such probabilistic learning occurs (Hudson Kam & Newport, 2005). Specifically, do learners acquire grammatical knowledge only when they are exposed to it above certain probability thresholds? Do they regularize probabilistic usage into grammatical rules in some contexts but not in others (Aslin & Newport, 2014; Gómez & Lakusta, 2004; Ross & Newport, 1996)? In Hudson Kam and Newport (2005), English-speaking six-year-olds were taught with artificial sentences with the VSO word order and articles following nouns (e.g., "ka") to mark grammatical gender, both of which do not exist in English. The results showed that children were able to acquire artificial articles not only when they were applied to all sentences but also when they were used in 60% of the sentences (i.e., not presented in 40% of the sentences). In addition, as reported by Ross and Newport (1996), deaf children were able to learn American

Sign Language (ASL) even though their parents made mistakes in ASL use. Specifically, while the parents had a 25–31% error rate in the use of morphemes, the children had only a 12% error rate. Creolization studies have also revealed that children are able to develop a more complex and regularized grammar even though they receive input that lacks complex morphology and syntax (Bickerton, 1984).

Taken together, these studies suggest that probabilistic learning is fairly robust since young learners are able to tolerate some degree of irregularity in the input and that there might be a minimum input threshold of regularities that suffices for abstraction. However, the way in which varying degrees of probabilistic structure influence syntactic marker learning, which is one of our interests, remains unclear.

Aim of the current study

As reviewed above, when learning from a case system through daily exposure, children may face challenges such as incomplete argument information in syntactic structures and infrequent encounters with them. Therefore, research questions arise concerning the impact of the "quality" and "quantity" of inputs upon language acquisition. First, how may the complexity of the argument structure affect the learning of the case markers? Does the acquisition system prefer sentence contexts with richer or less rich semantic information? Is age a moderator in this process? Second, how may the probability of structures influence learning? Does the complexity of the structure impact the effective exposure amount needed for learning?

To address these questions, we provide evidence from Japanese-speaking children who have the ability to acquire case markers despite challenges. We conducted two experiments, exposing them to the artificial case markers of subjects and objects in the training phase and testing whether they understood the case markers in the utterances in the test phase. In Experiment 1, children aged four, five, six, and seven years participated and were divided into two groups. One group of children watched acting-out videos with two animals interacting while being exposed to spoken sentences that described the videos with Japanese content words (i.e., animal names and verbs), artificial case markers and a full-argument structure in SOV order. The other group of children differed merely in that they heard sentences with the argument-omitted structure, i.e., SV and OV. Then, in the test phase, both groups of children were asked to choose between two videos of events with the acting roles reversed after hearing sentences with the artificial case markers and the full-argument structure, yet in OSV order. This order was used for testing because the children had to rely on the case markers (particularly the object marker) rather than the word order to achieve the correct sentence meaning. We expected that children would abstract and generalize the symbolic usage of artificial case markers no earlier than five years of age. Moreover, according to a previous study showing that Japanese children learned new verbs better in the argument-omitted structure than in the full-argument structure, we predicted that "the simpler the better" may also apply to case-marker learning, as the omitted structure outlines one of the acting roles and makes the identification of a case marker less demanding. In addition, given the potential impact of word order knowledge on case-marker learning, and the mixed findings in previous studies regarding whether Japanese-speaking children experience agent bias, we conducted a pretest to examine 4–7 year-old children's interpretation of agent roles within sentence contexts where word order is present but case markers are unknown.

In Experiment 2, we focused on the age at which children consistently demonstrated their ability to master artificial case markers in our laboratory setting. As shown in the findings of Experiment 1, seven-year-old children achieved 85% accuracy in learning with omitted structures; thus, they became the target subjects for Experiment 2. We finely manipulated the probabilities of the full-argument and argument-omitted sentences in the training phase to investigate the extent to which the children were sensitive to distributional information of structure in the learning case markers. We predicted that the children would achieve better performance when the argument-omitted sentences were the more probable structure (the full-argument sentences were the less probable structure) in the training input, on the basis of the results of Gómez and Lakusta (2004).

Experiment 1

In Experiment 1, we adopted a commonly used paradigm of artificial language learning for young children (e.g., Hudson Kam & Newport, 2005). In the learning phase, the participants learned the artificial linguistic information by utilizing other inputs that they were familiar with (e.g., listening to spoken sentences while watching acting-out videos). In the test phase, the participants had to respond on the basis of their newly learned knowledge of the artificial language.

Method

Participants

Twenty-eight 4-year-old (M = 4;6, range = 4;3–4;9), thirty-three 5-year-old (M = 5;6, range = 5;1–-5;11), twenty-eight 6-year-old (M = 6;7, range = 6;3–6;11) and twenty-two 7-year-old (M = 7;5, range = 7;2–7;11) Japanese-speaking children in several nurseries and schools in Tokyo, Hiroshima or Chiba Prefecture, Japan, participated in the artificial case-marker learning experiment.[3] In addition, twenty 4-year-old (M = 4;6, range = 4;1–4;9), nineteen 5-year-old (M = 5;6, range = 5;1–5;10), eighteen 6-year-old (M = 6;7, range = 6;1–6;10) and twenty 7-year-old (M = 7;5, range = 7;2–7;8) Japanese-speaking children in Japan participated in a norming study of stimuli on Zoom.

Stimuli

Two nonlexical syllables, *po* and *bi*, were selected as artificial case markers. *Po* follows the subject noun as the subject marker, and *bi* follows the object noun as the object marker. To create the sentences for learning, we selected two pairs of animals (i.e., monkey-cow, rabbit-bear) and two transitive verbs (i.e., “osu” and “tataku:” push and punch) with progressive tense; all of these are actual Japanese words. Consequently, 8 learning events were created, with each animal playing the agent or the patient in one event and playing the opposite role in the other event. Thus, they alternated between thematic roles in two events. For each learning event, three types of sentence structure were formed: full-argument sentences with the S-*po*-O-*bi*-V structure (6), subject-omitted sentences with the O-*bi*-V structure (7), and object-omitted sentences with the S-po-V structure (8). An example of one event is shown below. A video was also created for each learning event, with one animal (portrayed by an actor) performing one action toward the other animal (Table 2).

(6) S-*po*-O-*bi*-V: “saru-*po* ushi-*bi* oshiteiruyo/tataiteruyo:
monkey-NOM cow-ACC pushing/punching”
(The monkey is pushing/punching the cow)

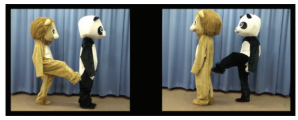
(7) O-*bi*-V: “ushi-*bi* oshiteiruyo/tataiteruyo:
cow-ACC pushing/punching”
(The cow was pushed/punched by (the monkey))

(8) S-*po*-V: “saru-*po* oshiteiruyo/tataiteruyo:
monkey-NOM pushing/punching”
(The monkey is pushing/punched (the cow)).

In addition, we created eight more test events with another two pairs of animals (i.e., “raion” and “tora:” lion and tiger; “panda” and “zou:” panda and elephant) and two transitive verbs (i.e., “hipparu” and “keru:” pull and kick). The sentence structure O-*bi*-S-*po*-V was used to

[3]We based our power calculation in the findings reported in Suzuki and Kobayashi (2017), a study that employed a similar task with a comparable sample size (*N* = 16 per condition) to investigate the effects of sentence type on verb learning in two-year-olds. For age 4 to age 6 in the present study, the statistical power for each subgroup ranged from 0.72 (*N* = 14) to 0.80 (*N* = 17). While the power values in the present study are slightly below the optimal range (above 0.8) for some subgroups, they are still within the acceptable range.

Table 2. Examples of stimuli.

(a) An example of the stimuli for the normality study of the experiment (same as in the posttest of the learning experiment)	
Audio Stimulus	OSV sentence: *laionsan bi pandasan po ketteruyo!* lion-ACC pand-NOM kick-prog (the lion is kicking the panda)
Video Clip	

(b) An example of the stimuli for the learning experiment.	
Learning **full-argument sentence (SOV)**: *sarusan po ushi bi oshiteiruyo!* monkey-NOM cow-ACC push-prog (The monkey is pushing the cow) **argument-omitted sentence (SV/OV)**: SV: *sarusan po oshiteiruyo!* monkey-NOM push-prog (The monkey is pushing) OV: *ushisan bi oshiteiruyo!* cow-ACC push-prog (The monkey is pushing (the cow))	Posttest (Same stimuli as in the norming test) OSV sentence: *laionsan bi pandas an po* lion-ACC pand-NOM *ketteruyo!* kick-prog (the lion is kicking the panda)
	

describe these test events, engendering eight test sentences. Each test event was paired with two videos. While the action remained identical in the two videos, the agent animal and the patient animal were reversed from one video to the other. In addition, three filler sentences with the structures of S-*po*-O-*bi*-V, S-*po*-V and O-*bi*-V were created. Like the test sentences, each filler sentence was paired with two videos in which the agent role and the patient role were reversed (see Appendix 2).

All the sentences for both the learning and test tasks were recorded by a female speaker. The sound and video stimuli were presented by PowerPoint (Version 2013).

Procedure of the norming test

We carried out a norm test to investigate how children at the target age comprehended the test sentences with the O-*bi*-S-*po*-V structure when they did not experience the learning phase. The participants performed the tests remotely via the online meeting tool Zoom. In each trial, they had to listen to a test sentence while two scenarios were visually presented on the screen. After the test sentence, the experimenter notified the young participant to respond by vocally asking, for example, "*docchi kana*? (which is it?)." The participant then needed to point to the scenario that was considered to match the spoken sentence (Table 2). The caregiver assisted in confirming the children's response by saying "*sounanda, arigatou* (I got your answer, thank you)." The entire experiment lasted for an average of 7 minutes (range = 4–9 minutes).

Procedure of the learning experiment

The participants attended the experiment in the presence of two experimenters. The participants took part in the experiment one at a time in a quiet room in the school, with one researcher conducting the experiment and the other taking notes. In the learning phase, the participants were instructed to learn a new word that they had not heard before ("Now, we are going to learn a new word which you haven't heard before, please infer the meaning of those words while you learn those words, then, we will test you later") and were randomly assigned to one of the two learning conditions to passively listen without response demand. In the full-argument learning condition, the participants were presented only with the sentences with the S-*po*-O-*bi*-V (see Appendix for the materials). Each sentence paired with the scenario was presented two times during the learning phase; as a result, 8 sentences were learned with *po* and *bi*, such that each marker occurred 8 times. In the argument-omitted learning condition, the participants were exposed to both subject-omitted (O-*bi*-V) and object-omitted (S-*po*-V) sentences during video viewing. Specifically, each S-*po*-V sentence paired with the scenario was presented two times, while each O-*bi*-V sentence paired with the scenario was also presented two times. In other words, the participants heard a total of 16 sentences in which they encountered *po* 8 times and *bi* 8 times. Therefore, the input amount of the artificial case marker did not differ for participants in the two learning conditions.

In the following test phase, the participants listened to the test sentences (including 8 O-*bi*-S-*po*-V test sentences and 3 filler sentences in other structures), each twice, and completed a forced-choice discrimination task similar to that in the norming test: The participant was notified by the experimenter to respond by pointing to the video considered matching (Table 2). When the participants finished the test phase, the experimenter asked them, "Now, what do you think the meaning of *po*/*bi* is?" ("*po*/*bi* wa nanndato omou?"). Approximately 21% of the participants could explain the meanings of *po* and *bi* for specific verbs but could not generalize these meanings to all verbs (e.g., "*po* is used for 'kick,' *bi* is used for 'kicked by somebody'"), whereas 7% (comprising one 5-year-old, three 6-year-olds and four 7-year-olds) were able to explain the meanings of *po* and *bi* completely and correctly (e.g., "*po* is for the one who does something, and *bi* is for the one who receives something").

The entire experiment, including the learning and test phases, lasted for approximately 13 minutes (range = 11–17 minutes). The participants were allowed to take breaks, although none of them requested breaks.

Data analysis

For the norming test, the percentage of interpretations of the first noun as an agent was calculated for each participant. For every age group, the overall probability was tested against the chance level (0.5) via a one-sample t test.

For the learning experiment, a generalized logistic mixed regression model (GLME) (Baayen et al., 2008) was performed, with *Condition*, *Age* and their interaction as the fixed factors and the participant and item as the random factors. The *Condition* with 2 levels was sum coded (−0.5 and 0.5). The variable Age was treated as a categorical variable and coded with a successive (forwards) difference coding system, resulting in three comparisons: age 4 vs. age 5, age 5 vs. age 6, and age 6 vs. age 7. The random effects included the intercept of the participant and item. The final model was as follows:

$$\text{glmer}(\text{preference}\sim\text{condition} * \text{age} + (1|\text{subj}) + (1|\text{item}), \text{family} = \text{binomial}$$

Results

Norming test results

Four-, five-, and six-year-old children showed no bias in interpreting the semantic roles of the nouns in the OSV sentences where the artificial case markers were used, as shown in Figure 1. The 4-year-

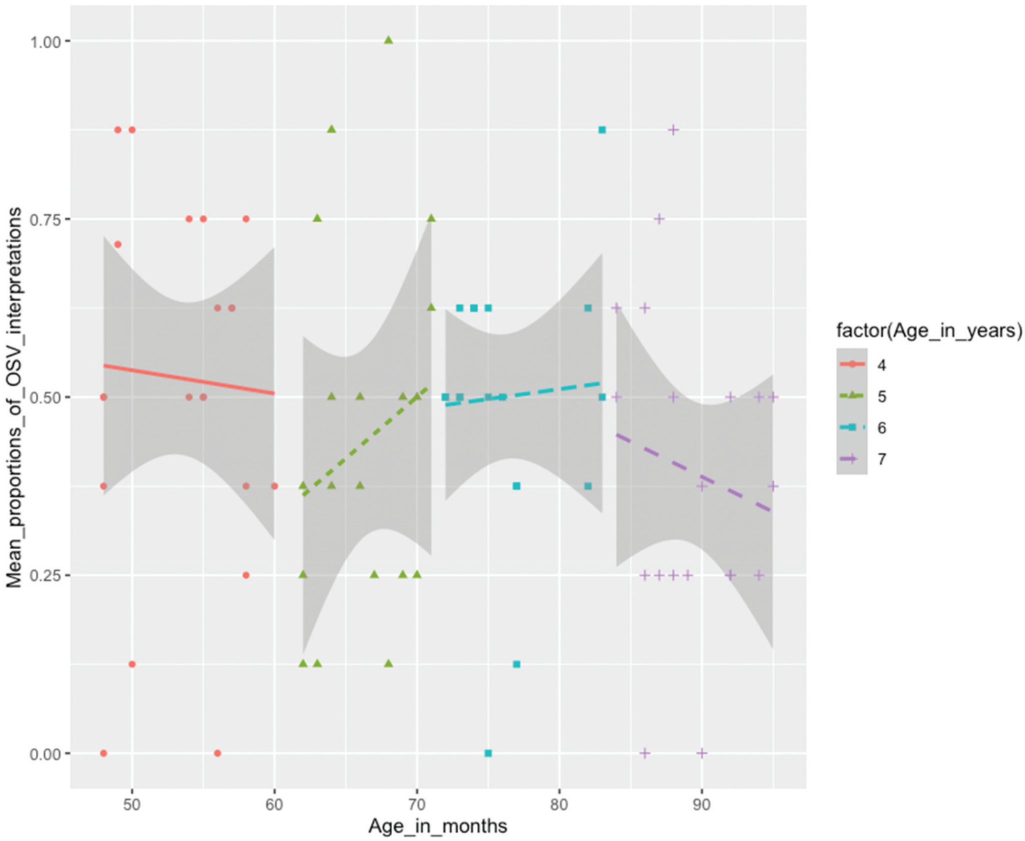


Figure 1. Percentage of guesses with OSV interpretation (i.e., interpreting the first noun as the object) in the pretest. Each dot represents the accuracy for each participant. The lines are the smoothing lines using Robust Linear Model, and the gray ribbons represent the standard error.

olds had 53%, the 5-year-olds 46% and the 6-year-olds 48% correct "guesses," which did not differ from the chance level revealed by the one sample t test (four-year-olds: $t(19) = 0.60$, $p = .554$; 5-year-olds: $t(18) = -0.53$, $p = .601$; 6-year-olds: $t(17) = -0.30$, $p = .767$). However, the performance of the 7-year-olds differed significantly from the chance level (accuracy: 38%; $t(19) = -2.49$, $p = .021$), indicating that they tended to interpret the first noun as an agent when they had no knowledge of the artificial case markers.

Learning experiment results

For the artificial case-marker learning test, Tables 3 and 4 show the number of participants and response accuracy by age and learning condition in the learning experiment, and Figure 2 shows the performance of different learning groups by month. Descriptively, whereas age 4 showed accuracy rates around 50% regardless of the learning condition, 5-, 6- and 7-year-old children who learned with omitted sentences exhibited a pattern of increasing accuracy over the months. However, learning with full SOV sentences was not associated with such a pattern at any age. Additionally, the 6-year-olds scored the best in the test, whereas the 7-year-olds seemed to rebound/degrade rather than further improve.

Statistically, the results of one sample t test for each age group of each learning condition indicate that age 4 showed chance-level performances regardless of what had been learned ($ps > .1$; also see

Table 3. Mean proportion of accuracy of the artificial case-marker learning test and the results of t test against chance-level (0.5) in experiment 1.

Age	Learning condition	Accuracy	*t*	*df*	*Pr* (> |t|)
Four	Argument-omitted	0.464	−0.634	13	.536
	Full-argument	0.458	−1.384	13	.189
Five	Argument-omitted	0.632	2.954	16	.009
	Full-argument	0.302	−4.372	15	<.001
Six	Argument-omitted	0.732	3.297	13	.005
	Full-argument	0.642	1.962	13	.071
Seven	Argument-omitted	0.875	6.093	11	<.001
	Full-argument	0.325	−4.118	9	.002

Table 4. Results of generalized logistic mixed-effects models of the artificial case-marker learning test in experiment 1.

Fixed Effect	Estimate	Std. Error	z value	Pr(>|t|)
Intercept	0.323	0.134	2.402	.016
LearningCondition	1.273	0.212	6.004	<.001
4 vs. 5	−0.164	0.263	−0.622	.534
5 vs. 6	−1.010	0.273	−3.65	<.001
6 vs. 7	0.179	0.332	0.541	.588
LearningCondition * (4 vs. 5)	−1.225	0.528	−2.320	.020
LearningCondition * (5 vs. 6)	0.962	0.542	1.773	.076
LearningCondition * (6 vs. 7)	−2.517	0.651	−3.867	<.001
Simple effects: Learning Condition effect at different ages				
Age 4	0.192	0.330	0.082	.561
Age 5	1.320	0.773	4.828	<.001
Age 6	0.522	0.581	0.899	.369
Age 7	3.122	0.644	4.847	<.001

Table 3). Age 5–7 receiving either learning type performed significantly different from chance-level ($ps < .01$), except for age 7 learning SOV ($p = .071$). The GLMM results revealed that there was a main effect of the learning condition ($\beta = 1.27$, SE = 0.21 $z = 6.00$, $p < .001$), suggesting that, generally, children who learned with argument-omitted sentences outperformed those who learned with SOV sentences in the OSV comprehension task (44% vs. 66%). A significant result was obtained between ages 5 and 6 among the three contrasts of age ($\beta = -1.01$, SE = 0.27, $z = -3.65$, $p < .001$). Importantly, Learning Condition interacted with the contrast of age 4 and age 5 ($\beta = -1.22$, SE = 0.52, $z = -2.32$, $p = .020$) and with the contrast of age 6 and age 7 ($\beta = -2.51$, SE = 0.65, $z = -3.86$, $p < .001$), implying different learning effects for different age groups. Therefore, further analyses were conducted to examine the effect of Learning Condition for each age group: it is significant for ages 5 ($\beta = 1.32$, SE = 0.77, $z = 4.82$, $p < .001$) but not for 4 ($p = .56$) and for ages 7 ($\beta = 3.12$, SE = 0.64, $z = 4.84$, $p < .001$) but not for 6 ($p = .36$). Alternatively, the age effect differed by learning condition. For children learning with omitted sentences, accuracy increased with age, with marginal significance between 4- and 5-year-olds ($\beta = -0.77$, SE = 0.40, $z = -1.90$, $p = .057$) and significant differences between 6- and 7-year-olds ($\beta = -1.08$, SE = .530, $z = -2.05$, $p < .040$; 5 vs. 6: 5 < 6: $\beta = -0.56$, SE = 0.42, $z = -1.33$, $p = .180$). Conversely, children who learned with full sentences exhibited a non-linear developmental pattern: 4-year-olds outperformed 5-year-olds, though not significantly ($\beta = 0.46$, SE = 0.34, $z = 1.34$, $p = .179$), while 5-year-olds significantly lagged behind 6-year-olds ($\beta = -1.48$, SE = 0.35, $z = -4.15$, $p < .001$), and 6-year-olds outperformed 7-year-olds ($\beta = 0.40$, SE = .530, $z = 3.63$, $p < .001$).

Discussion

Taken together, the results indicate that the development of the learning case system is not monotonic but rather a function of various capacities. First, our Japanese participants did not show a subject-first preference in interpreting two-argument sentences when case markers were

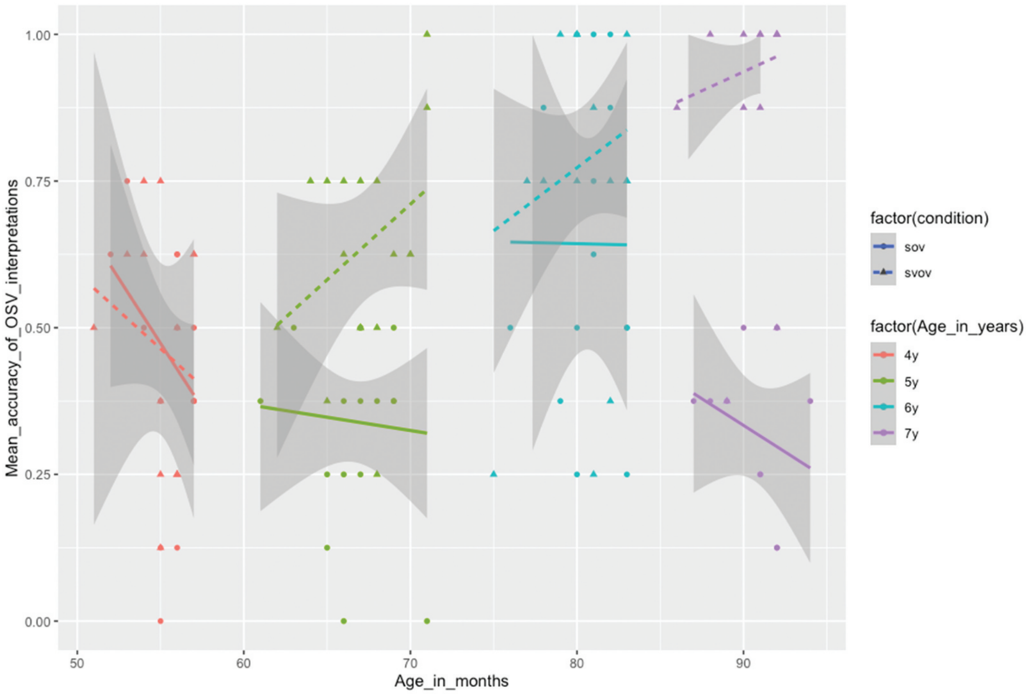


Figure 2. Experiment 1: Percentage of accuracy of interpreting OSV sentences in the test after the learning. Each dot represents the accuracy for each participant. The lines are the smoothing lines using Robust Linear Model, and the gray ribbons represent the standard error.

unknown (e.g., Zhao, 2022; and in the present study) until the age of seven, unlike German-speaking children did (e.g., Dittmar et al., 2008). In other words, the relationship between word order and argument identification in Japanese, which may be weakly inferred from daily input, has not been established as abstracted knowledge by children under seven years of age. Second, as Table 3 and Figure 2 show, the 4-year-old children in the present study were unable to learn the novel case markers in this paradigm, showing chance-level performance in the test regardless of exposure; however, the older children exhibited the utilization of new markers in OSV comprehension to some extent. Specifically, when learning markers with SV and OV structures, performance increased steadily with age from 63.2% at age 5 to 87.5% at age 7, suggesting that children from the age of 5 are able to syntactically represent novel sounds (*po*, *bi*) and make use of them in interpreting the roles of action in simple structures.

In contrast, whether Japanese children can learn novel case markers via full-argument sentences is far less clear. While the highest accuracy for learning with SOV sentences emerge in the 6-year-olds, with accuracies above 60%, the 5- and 7-year-olds correctly responded in only approximately 30% of the trials. We speculate that different sources may have contributed to this result. For the 5- and 6-year-olds who generally do not favor a subject-first structure over an object-first structure, the former group may have been sensitive during the learning phase, in which the SOV was the currently dominant structure, and thus adapted to the subject-then-object sequence to interpret the sentences in the test while paying little attention to the markers during the overall experiment. In contrast, the 6-year-old children may have noticed not only the dominant structure but also the case markers associated with the role assignment, leading to their weaker dependence on word order in interpreting the test sentences and improved task performance compared with the 5-year-olds (64.2%). However, children at 7 years tend to interpret the first noun as an agent (Figure 1: 62%); therefore, their results in the posttest were rather a conjunction of word order preference and the learning effect. To further clarify the marker-learning effect by factoring out the 7-year-olds' individual preferences, each child was given both a pretest and a posttest in Experiment 2.

Our results challenge the notion that grammar acquisition develops linearly with age. Instead, they support theories that propose general age milestones for acquiring certain types of linguistic knowledge (e.g., Arunachalam & Waxman, 2015). The distinct changes emerging at ages 5 and 7 were validated via a statistical approach that treats age as a categorical variable and compares adjacent age groups. While Figure 2 illustrates participant accuracy with smoothed fitting lines by month within each age group, importantly, observations in an age category are limited, and the linear fitting is somewhat arbitrary and should be interpreted with caution.

In conclusion, the findings of Experiment 1 suggest that Japanese children are able to abstract and generalize the symbolic usage of artificial case markers by age 5. Moreover, our prediction that argument-omitted sentences are more effective than full-argument sentences for case-marker learning is confirmed, in line with research on Japanese and Korean verb learning (e.g., Arunachalam et al., 2013; Imai et al., 2005).

Experiment 2

Experiment 1 provides evidence of "the simpler the better" for case-marker learning at ages 5 to 7 by providing the omitted/full structure in the learning phase with either all or no counts (either all omitted and no full sentences or all full and no omitted sentences). In Experiment 2, we further investigated the quantity issue in terms of the impact of exposure/learning frequency. We finely manipulated the probabilities of the full-argument and argument-omitted sentences in the training phase to investigate the extent to which the children were sensitive to the distributional information of the input structure in the learning case markers. Seven-year-old children were targeted because they are capable of mastering artificial case markers in the laboratory setting (i.e., 85% accuracy with omitted structure) and show a steady reliance on using word-order knowledge in interpretation. We predicted that the children would achieve better performance when the argument-omitted sentences were the more probable structure (the full-argument sentences were the less probable structure) in the training input, on the basis of the results of Gómez and Lakusta (2004).

Specifically, we controlled the percentage of exposure to the argument-omitted sentences and full-argument sentences to be 100% vs. 0%, 80% vs. 20%, 20% vs. 80% and 0% vs. 100%. This proportional design was a simulation of the daily input for children in which the full-argument and argument-omitted structures account for approximately 20% and 80% of transitive sentences with case markers, respectively (equivalent to 1.3% and 5% of the total speech input) (e.g., Matsuo et al., 2012).

In addition, the pretest was added to test how the 7-year-olds mastered the first-subject preference when encountering case markers. Thus, the contrast between the pretest and the posttest was considered the learning effect.

Method

Participants

Ninety-six Japanese-speaking seven-year-olds ($M = 7;5$, range = 7;1–7;11) in several nurseries and schools in Hiroshima or Chiba Prefecture, Japan, participated in this experiment. They did not participate in Experiment 1.

Stimuli and procedure

Materials from Experiment 1 were used. The participants were arranged into four groups based on learning type during the learning phase. The participants in the first group (SVOV 100% condition) were exposed to 10 O-*bi*-V sentences and 10 S-*po*-V sentences, i.e., novel markers, with 100% in argument-omitted sentences and none in full-argument sentences. The participants in the second group (SVOV 80% condition) were exposed to 8 O-*bi*-V sentences, 8 S-*po*-V sentences, and 4 S-*po*-O-*bi*-V sentences, i.e., novel markers, with 80% in argument-omitted sentences and 20% in full-argument sentences. The participants in the third group (SVOV 20% condition) were exposed to 2 O-*bi*-V sentences, 2 S-*po*-V sentences, and 16 S-*po*-O-*bi*-V sentences, i.e., novel markers, with 20% argument-omitted sentences and 80% full-argument sentences. The participants in the fourth group (SVOV 0% condition) were exposed to 20 S-*po*-O-*bi*-V sentences, i.e., 100% full-argument sentences but none argument-omitted sentences.

The entire procedure included the pretest (approximately 6 minutes), the learning phase (approximately 10 minutes) and the posttest (approximately 5 minutes) sequentially. In the pretest, the participants listened to the test sentences (including 8 O-*bi*-S-*po*-V test sentences and 3 filler sentences in other structures), which were identical to those used in Experiment 1, and completed forced-choice discrimination between the two scenarios by pointing. In the learning phase, each participant was randomly assigned to one of the learning types, as illustrated above. The procedure was similar to that in Experiment 1. After learning, the posttest was performed, in which the sentences were identical to those in the pretest and presented in random order. We compared the effectiveness of learning object case markers between the groups.

Data analysis

The generalized logistic mixed-effects model was used. The dependent measurement was the binary variable, i.e., making the correct OSV choice or not. One of the fixed factors was the Learning Type with four levels, i.e., SVOV 100%, SVOV 80%, SVOV 20% and SVOV 0%. This variable was coded via successive difference contrast coding, resulting in three contrasts: 0% vs. 20%, 20% vs. 80%, and 80% vs. 100%. The other fixed factor was Test Timing (pretest vs. posttest), which was valued at −0.5 and 0.5 in the model. The model also included the interaction of these two factors, thus forming 7 fixed effects. The random effects included the intercept of the participant and item. The final code was as follows:

$$glmer(Preference \sim LearningType * TestTiming + (1|subj) + (1|item), family = binomial$$

Results and discussion

Table 5 and Figure 3 show the number of participants and response accuracy by age and learning condition in the learning experiment.

The GLMM results revealed that the main effect of Test Timing was significant (pretest: 0.322; posttest: 0.643), $\beta = 1.81$, SE = 0.14, $z = 13.089$, $p < .001$, indicating that the seven-year-old participants

Table 5. Results of generalized logistic mixed-effects models of the artificial case-marker learning test in experiment 2.

Fixed Effect	Estimate	Std. Error	z value	Pr(>|t|)
Intercept	−0.082	0.144	−0.573	.567
0% vs. 20%	0.893	0.397	2.246	.024
20% vs. 80%	0.128	0.395	0.324	.746
80% vs. 100%	0.375	0.402	0.933	.350
Pre vs. Post	1.810	0.138	13.089	<.001
(Pre vs. Post) * (0% vs. 20%)	0.799	0.340	2.345	.019
(Pre vs. Post) * (20% vs. 80%)	1.537	0.370	4.147	<.001
(Pre vs. Post) * (80% vs. 100%)	0.663	0.416	1.594	.110
Simple effects: Learning effect for each learning type				
100%: Pre vs. Post	3.320	0.339	9.771	<.001
80%: Pre vs. Post	2.646	0.003	827.65	<.001
20%: Pre vs. Post	1.067	0.238	4.485	<.001
0%: Pre vs. Post	0.290	0.250	1.160	.246

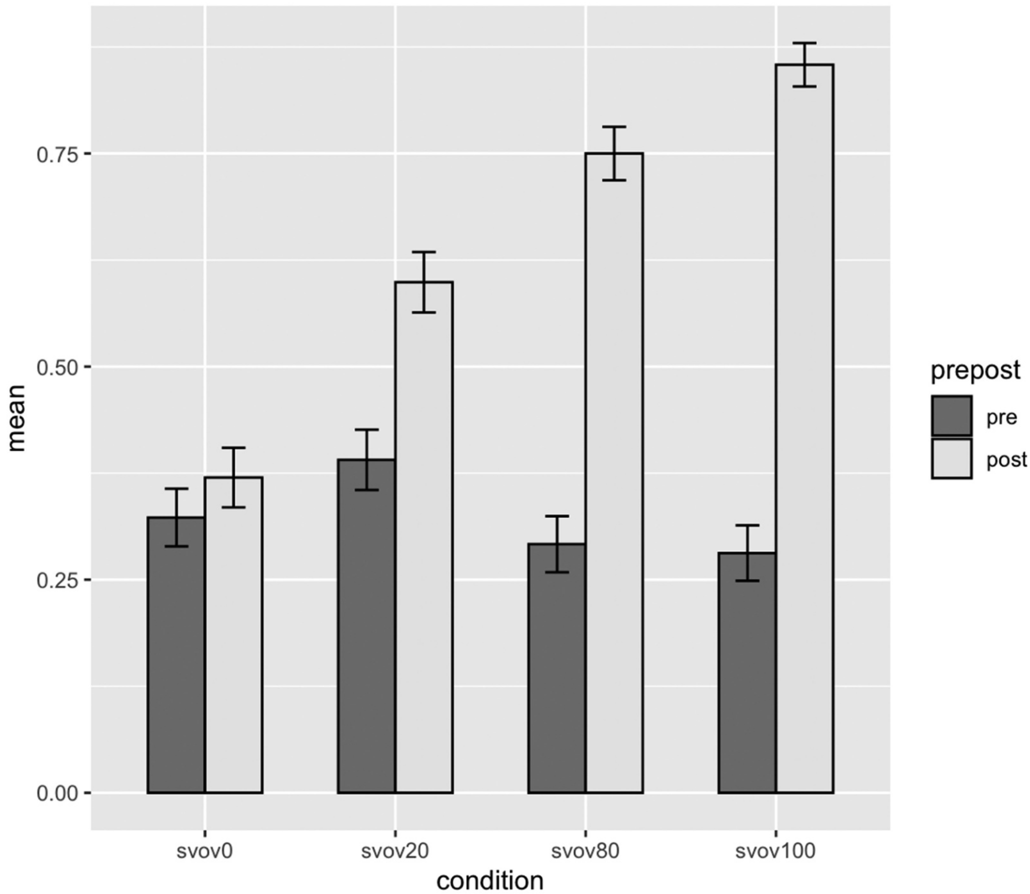


Figure 3. Experiment 2: Mean accuracy of interpreting the OSV sentences in the pre- and posttest (Note: error bars represent standard error). The numbers marked in the condition refer to the proportions of omitted structure (SV & OV) during the learning phase.

were generally able to learn the novel case markers during the short learning phase. For the factor Learning Type, the contrast of 0% vs. 20% was significant (0.346 vs. 0.495), $\beta = 0.89$, SE = 0.39, $z = 2.24$, $p = .024$, suggesting that the overall accuracy of learning with these two types of input differed. The main effects for the contrast of 20% vs. 80% (0.495 vs. 0.521) as well as that of 80% vs. 100% (0.521 vs. 0.568) were not significant (*p*s > .30).

Notably, Test Timing significantly interacted with the contrast of 0% vs. 20% ($\beta = 0.80$, SE = 0.34, $z = 2.34$, $p = .0190$) and with the contrast of 20% vs. 80% ($\beta = 1.54$, SE = 0.37, $z = 4.15$, $p < .001$), indicating that participants' learning performance improved significantly as they were exposed to more argument-omitted sentences: with the overall quantity of the novel markers remaining constant, the more simpler structures (and thus fewer complex structures) were used, the better case-learning performance was achieved. Although the interaction between Test Timing and the contrast 80% vs. 100% did not reach statistical significance ($\beta = .66$, SE = 0.42, $z = 1.59$, $p = .111$), the SVOV 100% group numerically outperformed the SVOV 80% group in the posttest (0.854 > 0.750), while performing similarly in the pretest (Figure 3). These results confirmed the advantage of argument-omitted structures in Japanese children's learning of case knowledge.

To explore the interactions further, we performed separate GLMMs for each of the learning type levels, with Test Timing as the primary predictor of interest, to assess its simple effect within each specific learning type. As Table 5 shows, the percentage of participants who learned case markers without simpler omitted structures (i.e., SVOV 0%) was not different between the pretest and posttest ($p = .246$). However, the other groups of participants, who were exposed to argument-omitted structures to some extent during the learning phase, showed a remarkable learning effect in the posttest (all ps < .001).

In conclusion, the results of Experiment 2 supported our prediction that Japanese children would improve their novel case-marker learning when the probability of the argument-omitted structure increased with a given (small) amount of marker exposure. Moreover, our findings revealed that learning was still effective even when the omitted sentences were not the more probable structure in the training input (i.e., 20% in the present study), in line with the findings of Gómez and Lakusta (2004). This evidence converges in suggesting fairly robust grammar rule learning. However, only the full-argument structure was not sufficient for children to manage the markers, at least in such a short experimental period, indicating that rich linguistic information interferes with, rather than facilitates, Japanese children's case acquisition system.

General discussion

In the present study, we explored the acquisition of function words by examining how Japanese children who speak a verb-final language that allows scrambled word order learn novel case markers in the transitive sentence context. We specifically investigated which of the two types of structure – argument-omitted sentences (i.e., with only the subject or only the object) that have relatively sparse linguistic information and full-argument sentences (i.e., with both the subject and the object) that have richer linguistic information – is effectively utilized by children to infer the use of novel markers. Our findings straightforwardly reveal the advantages and robustness of simpler sentences in children's learning of case markers. In the following, we discuss the type and frequency of useful linguistic information for case-marker learning, the cue validity of word order in the comprehension of Japanese transitive sentences and the age of acquisition of case markers from a crosslinguistic perspective.

When does "simpler is better" apply?

Our observation that simpler sentences outperform complex sentences in syntax learning is consistent with the results of Imai et al. (2005) and Arunachalam et al. (2013), who demonstrated that Japanese-speaking children and Korean-speaking children, but not English-speaking children, achieved better performance in new verb learning when argument-omitted sentences were given.

We considered two possible explanations for why sparse linguistic information is more useful for Japanese case-marker learning. One account, proposed by Imai et al. (2005), is that the sentence structures that occur more frequently in daily input (i.e., argument-omitted sentences, such as "X[4]-teiru: Verb-ing") facilitate learning since the children are more familiar with frequent structures and are thereby more able to allocate attention to new elements in a sentence. In our case, argument-omitted sentences were the more familiar structure for the children, as they make up 80% of transitive sentences in daily speech. This explains the crosslinguistic difference observed between Japanese- and English-speaking children because the frequency of occurrence of each grammatical item differs between these languages (Imai et al., 2005). Similarly, Jiang and Haryu (2013) also considered structure frequency to interpret why the number of arguments in a sentence is important for English-speaking children but not for Chinese-speaking children in distinguishing between transitive and intransitive verbs: one-argument transitive sentences are common in Chinese.

Another possibility is that the full-argument structure may negatively impact case-marker learning because it is associated with greater processing costs to decode information other than case markers, such as two or more entities to refer to and word order (Bernal et al., 2007; Jiang & Haryu, 2013; Lidz et al., 2007; Noble et al., 2011). The argument-omitted sentences contain less information to distract

[4]"X" here expresses an artificial verb. Imai et al. (2005) used artificial verb such as "neke-teiru: Verb-ing."

the children from the linguistic learning target. This proposal clearly supports our finding of an undetectable learning effect for the full-sentence learning group in Experiment 2. Notably, studies of intransitive verb learning also provide supporting evidence in favor of this proposal. For example, in Lidz et al. (2007), English-speaking two-year-olds were presented with new intransitive verbs (e.g., "blicking") in two types of sentences: sentences with high lexical content in which the agent was represented by a noun ("the flower is blicking") and sentences with low lexical content in which the agent was represented by a pronoun ("It is blicking"). Longer preferential viewings of the correct action video of "blicking" were observed for children who learned with a pronoun subject (i.e., sparse information) than for those who learned with a noun subject (i.e., rich information), arguably due to the redundant role of noun information in learning intransitive verbs that engage only one participant. Lidz et al. (2007), p. 25) mentioned that when learning transitive verbs, learners face the dual challenge of mapping two noun phrases to their referents and learning the verb. In this case, the lexical noun phrases provide more information because they help to identify the role played by each participant in the event labeled by the verb. However, in intransitive sentences, noun information is less important because only one noun appears with the intransitive verb. Rather, too much noun information may impose more processing costs on children when processing a sentence.

In summary, the current study, together with prior works, challenges the view that rich linguistic input (e.g., full-argument sentences, high-lexical-content sentences) always benefits language learning; rather, factors such as structure frequency and children's processing capacity should be accounted for.

How much effective linguistic information is needed for case-marker learning?

Unsurprisingly, Japanese-speaking children are able to acquire novel case markers from inputs with an 80% effective structure, i.e., argument-omitted sentences, because they should be familiar with such a structural distribution for case marker exposure. In the daily linguistic input that children receive, sentences with object case markers where the argument is omitted constitute 5% of the total speech input, while full-argument sentences make up 1.3%, as reported in Matsuo et al. (2012). This corresponds to a ratio of approximately 80% to 20%. More interestingly, the case-marker learning effect remains robust even if the frequency of effective argument-omitted sentences is low and less probable (i.e., 20%). Our results are fundamentally consistent with previous works highlighting the robustness of syntactic learning, suggesting that an abundant amount of effective input may not be needed for the regularization and abstraction of syntactic rules (e.g., Gómez & Lakusta, 2004; Hudson Kam & Newport, 2005; Ross & Newport, 1996).

Gómez and Lakusta (2004) examined the probability of effective input for the successful learning of artificial word-combining rules on the basis of form-based features (monosyllabic vs. disyllabic) by 12-month-old infants. They reported that infants exposed to stimuli with 83% effective input (consistent with rules) generalized the artificial grammatical rules to test words not presented in training, whereas those exposed to 67% effective input did not. The ratio illustrates a threshold of effective input needed for rule abstraction, which could eliminate interference from ineffective input (i.e., stimuli inconsistent with the artificial rules) at this age. In our study, the artificial case markers consistently signaled subjects and objects in both omitted and SOV sentences. However, learning with SOV sentences may bias participants toward subject-then-object interpretation during the learning phase, potentially causing a negative priming effect upon comprehending the OSV structure in the subsequent test phase, similar to the inconsistency effect observed by Gómez and Lakusta (2004). Nevertheless, our results showed that, for the 7-year-olds, 20% effective input (i.e., omitted sentences) is sufficient for learning the case markers *per se*, (partially) counteracting the priming effects induced by the experimental settings and the agent bias acquired through daily use.

Learning improves when effective input is increased. The findings of Experiment 2 clearly reveal a greater improvement in learning for the 80% condition than for the 20% condition. A similar observation was made in the context of deaf children's learning of ASL, where their performance in morpheme usage correlated with their parents' accuracy (Singleton & Newport, 2004). Specifically, children struggled to learn if their parents made errors at a rate of 55–58% but achieved 82% accuracy if their parents' erroneous usage decreased to approximately half (25–31%).

Do Japanese-speaking children utilize word order knowledge to comprehend sentences?

Previous studies have claimed that Japanese children seemingly interpret NNV (Noun-Noun-Verb) sentences on the basis of word-order knowledge: they often interpret the first noun in the sentence as an agent since the canonical word order in Japanese is SOV, also known as agent bias (Hayashibe, 1975). In the current study, however, the participants aged four to six years did not show agent bias, which confirmed the findings of Zhao (2022) that used sentences without case markers. As mentioned earlier, early studies tested Japanese sentences that included the familiar case markers *ga* and *wo*. The presence of these markers may have interacted with the interpretation of word order, potentially enhancing the "agent bias" observed in those studies. Furthermore, our results may offer an alternative interpretation for the difference noted by Zhao (2022) between Japanese monolinguals and bilinguals. The bilingual Japanese L2 speakers at 6–10 years of age displayed strong word order bias, probably due to the L1-to-L2 influence, as proposed by the author, or simply due to their older age – a phenomenon also shared by Japanese native speakers at age 7. The late acquisition of agent bias was also captured in a recent study that investigated Japanese-speaking children (4–6-year-olds) comprehending Subject Cleft sentences (neko-o oikake-teiru no wa inu(-*ga*) da: cat-ACC chase-PROG C TOP dog-NOM COP: "It is a dog that is chasing the cat") and Subject Right Dislocation sentences (e.g., Neko-*wo* oikake-teiru yo, inu-*ga*: cat-ACC chase-PROG SFP dog-NOM: "(It is) chasing a cat, the dog") (Shimada et al., 2020). Although both types of sentences had noncanonical word order with the "cat" at the sentence-initial position, young participants were only "misled" by the agent-first strategy in the Subject Cleft sentences but correctly identified the agent ("dog") and the patient ("cat") in the Subject Right Dislocation sentences, presumably owing to the influence of the sentence "processing burden" (Shimada et al., 2020, pp. 594–595). In addition, previous studies employing sentences with different structures repeatedly reported that the preference of identifying the first noun as the agent is stronger in older (4- and 5-year-olds) than in younger children (3-year-olds) and is modulated by sentence word order (Hakuta, 1982; Shimada et al., 2020).

Compared to German, in which 79% of transitive sentences are subject-first (see Table 1), Japanese-speaking children are exposed to subject-first sentences (SV and SOV) in only approximately 20% of children's inputs and to object-first sentences (OV)[5] in more than 60% (Ishii, 1999; MacWhinney, 2000). Therefore, according to the competition model, the cue validity discrepancy may well explain the cross-language difference in word order knowledge acquisition.

Is the acquisition of Japanese case markers "Late"?

Japanese-speaking children, like German-speaking children, accomplish the development of a case marker system at a relatively late stage (e.g., Dittmar et al., 2008; Suzuki, 2007), in contrast to Korean- and Turkish-speaking children, who demonstrate the ability to use case markers in subject–object identification in transitive sentences by age four (e.g., Özge et al., 2019; Song et al., 1997). However, it should be noted that some of these conclusions regarding the "significant age" did not arrive from identical criteria or procedures. While both Korean- and Japanese-speaking children developed case markers with an accuracy of approximately 60% at age 4 and up to 80–90% at age 5, the critical acquisition age was determined to be age 4 for Korean-speaking children (Song et al., 1997) but age 5 for Japanese-speaking children (Suzuki, 2007). Moreover, German-speaking children were found to be "late" (i.e., at age 7) at mastering case markers in act-out tasks (Dittmar et al., 2008) but were revealed to have a comparable developmental pattern (Özge et al., 2022) with Turkish-speaking children when both groups were measured with preferential looks (Özge et al., 2019).

[5]Object first sentence only contain the OV sentence, since the OSV sentence was not observed in this corpus.

Along this line, by employing the artificial language paradigm, we observed a developmental pattern in which Japanese-speaking children are equipped and capable of quickly learning novel case markers in simple structures starting from the age of 5. On the other hand, the age of 7 is believed to be a milestone, too, because by that age, word order knowledge seems to have been formed, which interferes with children's ability to master the case markers and delays the full establishment of case system principles.

Before we can confidently draw our conclusions, we acknowledge that the replication of our findings in future studies with larger sample sizes would be beneficial for consolidating our understanding. Nevertheless, we have evidence to ensure the robustness of our results. First, while the 7-year-old group in Experiment 1 had the smallest sample size, we were able to replicate the observed pattern in Experiment 2, which employed a larger sample size (24 for each learning type). This replication strengthens our confidence in the generalizability of our results. Second, the sample size for ages 4 to 6 in Experiment 1 was similar to that of a previous study (Suzuki & Kobayashi, 2017) that used a comparable task with a similar sample size ($N = 16$ per condition) and successfully revealed the effects of sentence type on verb learning in two-year-olds. Moreover, to capture more subtle and delicate developmental patterns, future studies should aim for a more evenly distributed age-in-month participant pool. This would enable the treatment of age-in-month as a continuous variable, facilitating a more nuanced analysis of developmental changes.

Conclusion

To conclude, with the evidence from Japanese-speaking children in learning artificial case markers, this study elucidates the impact of structural complexity and the amount of inputs upon the acquisition of a case system. Two experiments both demonstrate that simpler structures are more beneficial for learning case markers. Specifically, the findings of Experiment 1 reveal the development of case marker knowledge and suggest that it interacts with the development of word order knowledge. Moreover, Experiment 2 demonstrates a robust learning effect of case markers even when argument-omitted sentences were less prevalent in the input, in contrast with the limited learning outcomes when only learning with full-argument sentences.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendices

Appendix 1. Learning materials

	SOV learning condition
1	sarusan po ushisan bi tataiteruyo (monkey po cow bi punching)
2	ushisan po sarusan bi tataiteruyo (cow po monkey bi punching)
3	sarusan po ushisan bi oshiteruyo (monkey po cow bi pushing)
4	ushisan po sarusan bi oshiteruyo (cow po monkey bi pushing)
	SVOV learning condition
1	saru po tataiteruyo (monkey po punching)
2	saru bi tataiteruyo (monkey bi punching)
3	ushi po tataiteruyo (cow po punching)
4	ushi bi tataiteruyo (cow bi punching)
5	saru po oshiteruyo (monkey po pushing)
6	saru bi oshiteruyo (monkey bi pushing)
7	ushi po oshiteruyo (cow po pushing)
8	ushi bi oshiteruyo (cow bi pushing)

Appendix 2 Test materials

	Test OSV sentences (Eight sentences)
1	Raionsan bi pandasan po ketteruyo (lion bi panda po kicking)
2	pandasan bi raionsan po hippateruyo (panda bi lion po pulling)
3	Raionsan bi pandasan po hippatteruyo (lion bi panda po pulling)
4	pandasan bi raionsan po ketteruyo (panda bi lion po kicking)
5	usagisan bi kumasan po ketteruyo (rabbit bi bear po kicking)
6	Kumasan bi usagisan po hippatteruyo (bear bi rabbit po pulling)
7	usagisan bi kumasan po hippatteruyo (rabbit bi bear po pulling)
8	Kumasan bi usagisan po ketteruyo (bear bi rabbit po kicking)
	Filler sentences (three sentences)
1	Raionsan po ketteruyo (lion po kicking)
2	Raionsan bi ketteruyo (lion bi kicking)
3	Raionsan po pandas an bi ketteruyo (lion po panda bi kicking)