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Children's On-line Processing of Scrambling in Japanese

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Abstract This study investigates the on-line processing of scrambled sentences in Japanese by preschool children and adults using a combination of self-paced listening and speeded picture selection tasks. The effects of a filler-gap dependency, reversibility, and case markers were examined. The results show that both children and adults had difficulty in comprehending scrambled sentences when they were provided as reversible sentences. The reversibility effect was significant for children, whereas the interaction of reversibility and a filler-gap dependency was significant for adults. However, this does not indicate that children's parsing is fundamentally different from that of adults. For those children who processed the nominative and accusative case markers equally fast, the reactivation of the dislocated constituent was observed in the gap position. These results suggest that children's processing is basically the same as adults' in that their sentence processing is incremental and they parse a gap to form a filler-gap dependency.

Keywords Children's sentence processing · Japanese · Scrambling · Filler-gap dependencies

Introduction

A traditional approach to language acquisition studies investigates children's linguistic knowledge. Its typical way is to seek the emergence of certain structures, the frequency of their use, and the types and the number of errors in the children's speech. Within this research domain, many studies have disclosed children's early linguistic knowledge (see, for example, Crain and Thornton 1998; Guasti 2004), whereas relatively little attention has been paid to what is responsible for their linguistic performance including occasional errors, abbreviated responses, and individual differences.

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Researchers have tried to account for these aspects mainly from two perspectives. One considers that children's non-adult performance is due to their immature discourse-pragmatic abilities (e.g., Crain and Thornton 1998; Gualmini 2004). It is often suggested that the development of discourse-pragmatic abilities is late compared with the development of syntax (e.g., Avrutin and Wexler 1992; Schaeffer 2000), and excluding these factors often discloses children's linguistic knowledge (e.g., Crain et al. 1996; Otsu 1994). The other perspective suggests that children's difficulty lies in their limited resources of sentence processing as well as pragmatic factors (e.g., Conroy et al. 2009; Musolino and Lidz 2006; Trueswell et al. 1999). Recent advancements in on-line sentence processing research reveal how people produce and understand sentences in real-time, and the adapting this method to children (see Sekerina et al. 2008 for a summary) has disclosed interesting characteristics of children's sentence processing (e.g., Felser and Clahsen 2009; Sekerina et al. 2004; Trueswell and Gleitman 2007). Following this approach, the present study investigates Japanese-speaking children's on-line processing of very simple and basic structures: simple SOV and OSV sentences. In particular, this study is concerned with how children parse the OSV sentences that involve a filler-gap dependency.

Although there are many child language studies in Japanese, only a few of them explore on-line sentence processing (Mazuka 1998), and none focus on preschool children. This is the first to investigate how Japanese-speaking preschool children process sentences in real-time, and the findings should indicate the way to future research in this vein.

Scrambling in Japanese

Japanese is a head-final language, allowing relatively free constituent orderings provided the verb stays at the end of a sentence. A canonical constituent order in Japanese is SOV, as in (1), where a subject is marked with nominative *-ga* and a direct object with accusative *-o*. An OSV version in (2), denoting the same meaning, is a non-canonical order derived by the movement of a direct object, an operation dubbed 'scrambling' (e.g., Saito 1985; See Nemoto 1999 for a summary).

(1) Miki-ga Mao-o hometa.
Miki-Nom Mao-Acc praised
'Miki praised Mao.'

(2) Mao-o Miki-ga ____ hometa.
Mao-Acc Miki-Nom praised
'Miki praised Mao.'

In (2), a direct object moves from its original position to a sentence-initial position, creating a gap as indicated by underlining. Within the Principles and Parameters approach and the Minimalist Program (e.g., Chomsky 1981, 1995, 1998) trace or copy of the moved constituent is assumed in the gap position.

From a psycholinguistic perspective, the psychological reality of the empty element has been investigated to see whether its reactivation is observed in the gap position (e.g., Bever and McElree 1988; Nicol 1993). In the case of Japanese scrambling in (2), a parsing operation proceeds as follows. When the parser encounters the filler (e.g., *Mao-o* in (2)), it starts looking for a gap to form a filler-gap dependency. At this point, however, the parser cannot decide whether or not the accusative-marked NP is a moved object. Because Japanese allows null arguments, the accusative-marked NP is equally likely to be part of an OV sentence, with an omitted subject. This ambiguity is solved when the parser finds the gap, at which point the filler is reactivated and some measurable timing effect reflecting an increased processing cost should be observed. This is an incremental view on sentence processing in which adult native speakers interpret an incoming word without waiting for a verb or the rest of the sentence (see, e.g., Mazuka et al. 2002; Miyamoto 2006 for a summary). This view contrasts with the delay model (e.g., Pritchett 1991), which claims that when making parsing decisions, the parser waits for a certain element such as a verb in a sentence. Currently, there is strong and extensive evidence that sentence processing is incremental in nature, even in verb-final languages like Japanese (e.g., Miyamoto 2006, 2008 for a summary).

Many on-line processing studies have examined adult native speakers of Japanese to explore the scrambling effect. Chujo (1983) and Tamaoka et al. (2005) used a speeded judgment task, where participants were asked to read a sentence and judge as soon as possible whether or not it made sense. They found that judging OSV sentences took longer than SOV sentences. However, this method cannot identify a difficult region in a sentence, and the exact source of the longer judging times required for scrambled sentences is thus implicit.

In order to detect a difficult region, a self-paced reading method has typically been used. Yamashita (1997) first explored the effect of scrambling using this method on a variety of constituent orders of the double object construction, although she failed to observe such an effect. This seems to be due to using relatively easy sentences in this experiment. Later, for the same construction, Miyamoto and Takahashi (2002b) reported the effect of scrambling using the following very complex sentences in a self-paced reading paradigm.

(3) Ofisu-de [$_{\mathrm{CP}}$ syokuin-ga [$_{\mathrm{RC}}$ kakarityoo-ni otya-o dasita] zyosee-o teineini hometa-to]
office-Loc employee-Nom manager-Dat tea-Acc served woman-Acc politely praised-Comp
Aiharasan-ga hanasiteita.
Aihara-Nom said
'At the office, Aihara said that the employee politely praised the woman who had served tea to the manager.'

(4) Ofisu-de [$_{\mathrm{CP}}$ syokuin-ga [$_{\mathrm{RC}}$ otya-o kakarityoo-ni dasita] zyosee-o teineini hometa-to]
office-Loc employee-Nom tea-Acc manager-Dat served woman-Acc politely praised-Comp
Aiharasan-ga hanasiteita.
Aihara-Nom said
'At the office, Aihara said that the employee politely praised the woman who had served tea to the manager.'

Both sentences involve a relative clause modifying the direct object (*zyosee-o*) of an embedding clause, and the structure of this relative clause is the focus of investigation. The relative clause in (3) displays canonical order (i.e., the dative-accusative order), whereas the one in (4) scrambled order (i.e., the accusative-dative order). Miyamoto and Takahashi (2002b) discovered that the region involving the gap of a scrambled object (*kakarityoo-ni*) in (4) took longer to read than the corresponding region (*otya-o*) in (3). This suggests that parsing scrambled sentences requires extra costs in the gap position. Using complex sentences put an extra burden on a parser and memory, which seems more likely to disclose the effect of scrambling.

Using a cross-modal priming task, Nakano et al. (2002) tested a sentence involving a long-distance scrambling applied to the double object construction to examine whether the fronted object (i.e., filler) was primed at the gap position. The overall results showed no reactivation effect at the gap position, but their investigation into the participants' working memory capacity revealed that, in the high span group, the reactivation rates were significantly higher in the gap position than in the other position, whereas no such effect was observed in the low span group. On the other hand, Shibata et al. (2006) used indirect priming in the same method to test the simple OSV structure and reported similar findings. Although they did not observe the reactivation effect at the gap position for an entire group, they observed the effect only for the group of participants with fast lexical decision latencies.

So far, the effect of scrambling was observed in the limited cases with relatively long and complex experimental sentences or where the experimental task required a high working memory capacity.[1] However, neither of these conditions is ideal for testing child participants.

One study observed the effect of scrambling using very simple sentences without requiring a high working memory capacity. Mazuka et al. (2002) compared the following SOV with OSV, among other types, in an eye-tracking paradigm.

(5) Mariko-ga otooto-o yonda.
Mariko-Nom brother-Acc called
'Mariko called the younger brother.'

(6) Otooto-o Mariko-ga yonda.
brother-Acc Mariko-Nom called
'Mariko called the younger brother.'

Participants were told to read a sentence on a screen as quickly as they normally do, and their eye-movement was recorded. The results indicated that the second argument of OSV (*Mariko-ga*) in (6) took longer to process than that of SOV (*otooto-o*) in (5), concerning the number of first pass regressive eye-movement, total gaze time, and total number of regressive eye-movements. This suggests that even in this simple OSV sentence, the region involving a gap requires extra time to read.

Generally, the results of these on-line studies provide the support for the incremental processing. Moreover, they suggest that the dislocated constituent is reactivated to form a filler-gap dependency when a parser encounters a gap. However, this effect is often concealed, depending on experimental methods and sentences. In order to observe the same robust effect as the eye-tracking method using simple auditory stimuli for children who are not literate, the present study selected a self-paced listening task. This method and its impact on children's on-line processing are explained later.

Acquisition of Word Order and Case in Japanese

Some off-line studies have well documented children's word order and case in Japanese sentence comprehension. This section briefly reviews these previous acquisition studies and relevant research.

[1] Another on-line method used to investigate Japanese scrambling involves a probe recognition task. Nakayama (1995), and Miyamoto and Takahashi (2002a), examining the reactivation effect in complex SOV and OSV sentences, reported contradictory results. This task is very sensitive to recency effect (Nakayama 1995) and is criticized that a probe word at the end of a sentence may simply reflect the sentence-final wrap-up processes (Clahsen 2008).

Japanese preschool children often misinterpret OSV sentences as if they were SOV when the sentences are reversible (e.g., Hayashibe 1975; Iwatate 1980; Otsu 1994). Taking the first NP as agent and the second as patient, the children use the agent-patient strategy in sentence comprehension in experimental situations (e.g., Hayashibe 1975). However, 3- and 4-year-old children can comprehend OSV correctly if the sentence is provided in context (Otsu 1994), which suggests that preschool children do not lack the knowledge of scrambling, and that the case-marking cue is not fully utilized for sentence comprehension.

Researchers have observed an asymmetry between nominative and accusative in the children's use of case markers as cues for sentence comprehension. Using single-argument sentences where either a subject or a direct object of a transitive verb was overtly used, Iwatate (1980) found that 3- and 4-year-old children comprehended SV sentences better than OV sentences. Suzuki (2007) examined a much wider age range and reported that even 5-year-old children often failed in comprehending OV sentences correctly, but 6-year-old children comprehended both SV and OV sentences correctly more than 90 % of the time. Whereas individual differences are observed among older children (Suzuki 2011), overall tendencies in the previous studies indicate the children's relative difficulty with the accusative case marker.

These facts, however, do not indicate a deficit in children's structural knowledge of scrambling. The discourse context helps children interpret OSV correctly (Otsu 1994) and helps facilitate the correct interpretation of OV sentences as well (Suzuki 2007). Moreover, Suzuki and Yoshinaga (2004) demonstrate that preschool children certainly refer to the gap of the fronted direct object in the OSV with a floating quantifier associated with the direct object. These results suggest that Japanese preschool children parse a gap in OSV sentences just as adults do.

Children's parsing of filler-gap dependencies is observed by on-line studies in other languages. Love (2007) and Roberts et al. (2007) have found the effects of a filler-gap dependency in the comprehension of relative clauses by English-speaking preschool children. The target structure of these studies is the relative clauses with a direct/indirect object gap, shown in (7), from Roberts et al. (2007).

(7) John saw the peacock to which the small penguin gave the nice birthday present ___ in the garden last weekend.

In this sentence, the filler 'the peacock' should be retained until s/he encounters an appropriate gap position indicated by underlining. In a cross-modal picture priming task by Roberts et al. (2007), a participant listened to the sentence, and s/he was required to decide whether the visually presented stimuli is alive. Either a picture identical to the filler ('the peacock') or unrelated one was shown on a computer screen at either the gap or control position. Some children's reaction times to the correct responses show that their reaction times to identical targets at the gap position were faster than both reaction times to unrelated targets in this position and reaction times to identical targets in the control position. These results are consistent with those reported by Love (2007), who virtually used a similar task. These studies indicate that at least some English-speaking preschool children do parse a gap in real-time sentence processing. Considering the evidence in English and that reported in the previous Japanese off-line studies, I predict that an on-line method reveals incremental processing and the effect of filler-gap dependencies in Japanese-speaking children's sentence comprehension.

The Present Study

The present study explores the effect of scrambling in children's sentence processing. I hypothesize that sentence processing by Japanese-speaking preschool children is essentially the same as adults'. If this is true, children's parsing is incremental in nature. Moreover, this predicts that, in a scrambled sentence, increased reaction times should be observed in the gap position due to a filler-gap dependency. The reactivation of the dislocated constituent should occur in this position.

In addition to a filler-gap dependency, this study examines the effect of reversibility. Reversibility refers to the exchangeability of component NPs without affecting the grammaticality of a sentence, as in sentences (5) and (6). Although reversibility is one of the crucial factors that determine the acceptability of a sentence, its effect has not been systematically investigated in the on-line processing studies previously introduced. Therefore, I consider its plausible cost independent of a filler-gap dependency. When a parser encounters the second animate NP in OSV (6), for example, it discovers that the sentence may be reversible and the processing speed may be slowed down. However, because the second NP in the OSV is the region that involves a gap, two plausible factors for the slow-down are confounded here, and it is impossible to discern whether the delay is due to a filler-gap dependency, reversibility, or both. A potential solution compares reversible sentences with non-reversible ones in both SOV and OSV patterns. The current study adopts this experimental design.

The other factor investigated in this study is the processing cost of case markers. Case markers such as -*ga* and -*o* may have different processing loads. Miyamoto and Takahashi (2002b) consider the possibility that nominative -*ga* is more costly than accusative -*o* due to the semantic functions of -*ga* (Kuno 1973): nominative -*ga* often expresses exhaustive listing, whereas accusative -*o* has no such function. However, the eye-tracking experiment in Mazuka et al. (2002) reported no difference in the reading times between the first NP in SOV and that in OSV by adult Japanese speakers. I am predicting the opposite effect for children. That is, accusative -*o* may be more costly than nominative -*ga*. As mentioned, preschool children cannot fully utilize case-marking cues for sentence comprehension. They have difficulty with accusative -*o*, compared with nominative -*ga*, witnessed as comprehension errors in the off-line studies (Iwatate 1980; Suzuki 2007, 2011). This fact suggests that processing an accusative-marked NP takes more time for children than a nominative-marked NP, whereas no such difference should be observed for adults. The effect of case markers is tested in the first NPs of SOV and OSV as there is no gap in this region, and the consequences of this effect on the second NPs are considered.

The present study adopted a self-paced listening task. This task, often used for child participants and those with reading task difficulties, has powerful measurements for syntactic parsing to examine whether a slow-down occurs in a particular region of a sentence (Ferreira et al. 1996). A speeded picture selection task was also done for each sentence comprehension trial. There are two purposes of this task. One is to discern correct responses from incorrect ones as a comprehension test. The results identify poor comprehenders who do not reach 80 % correctness overall. These participants are excluded from the reaction time analysis. Also, only correct responses are considered for the listening time analysis in a self-paced listening task. The other purpose is to investigate the relationship between sentence comprehension and its reaction times. Comprehension difficulty usually increases reaction times, but there may be speed-accuracy trade-off effects: the increased reaction times may lead a listener to a correct interpretation. A traditional off-line picture selection task is not informative about this possibility, but the speeded picture selection task used in this study should disclose whether this occurs.

Methods

Participants

Fifty-six native speakers of Japanese participated in the experiment. There were 26 children and 30 adults. The children were all preschoolers whose ages ranged from 5;9 to 6;7 (mean age = 6;3). There were 13 boys and 13 girls. The adult participants were all university students, and their ages ranged from 19;11 to 25;3 (mean age = 21;6). There were 16 males and 14 females. The adult participants served as a control group.

Materials

There were four types of experimental sentences with four tokens. The constituent order was either SOV or OSV and they were provided as either reversible sentences (R) or non-reversible sentences (N), as shown in the following examples.

(8) Kinoo / kooen-de / inu-ga / buta-o / osimasita./ (SOV-R)
yesterday park-Loc dog-Nom pig-Acc push
'Yesterday in a park a dog pushed a pig.'

(9) Kinoo / kooen-de / inu-ga / itigo-o / tabemasita./ (SOV-N)
yesterday park-Loc dog-Nom strawberry-Acc ate
'Yesterday in a park a dog ate a strawberry.'

(10) Kinoo / kooen-de / buta-o / inu-ga / osimasia./ (OSV-R)
yesterday park-Loc pig-Acc dog-Nom push
'Yesterday in a park a dog pushed a pig.'

(11) Kinoo / kooen-de / itigo-o / inu-ga / tabemasita./ (OSV-N)
yesterday park-Loc dog-Nom strawberry-Acc ate
'Yesterday in a park a dog ate a strawberry.'

Animal entities were used as both subject and direct object in the reversible patterns. In the non-reversible sentences, animal entities and foods were used as subject and inanimate direct object, respectively. All sentences began with *kinoo* 'yesterday', followed by a place word.

Four reversible verbs were used in (8) and (10): *tataku* 'hit,' *keru* 'kick,' *kamu* 'bite,' and *osu* 'push.' In the non-reversible patterns in (9) and (11), the followings verbs were used: *taberu* 'eat,' *nameru* 'lick,' *kaziru* 'bite,' and *sawaru* 'touch.' For each verb, animate-animate pairs or animate-inanimate pairs were selected from *panda* 'panda,' buta 'pig,' *kitune* 'fox,' *saru* 'monkey,' *usi* 'cow,' *hituzi* 'sheep,' *tanuki* 'raccoon,' *tora* 'tiger,' *kaba* 'hippo,' *kaeru* 'frog,' *nezumi* 'mouse,' *koara* 'koala bear,' *zoo* 'elephant,' *usagi* 'rabbit,' *neko* 'cat,' *itigo* 'strawberry,' *suika* 'watermelon,' *banana* 'banana,' *mikan* 'orange,' *keeki* 'cake,' *tomato* 'tomato,' *ringo* 'apple,' and *kyuuri* 'cucumber.' The pairs were formed so that each word has the same number of mora. For each pair, SOV and OSV sentences were created, providing two sets of experimental sentences. One set was used for half of participants and the other set for the remaining participants, so that each participant would hear the same pair with a particular verb only once in the experiment and any potential effect of argument-verb pairs could be counter-balanced.

Sound files, used for a self-paced listening task, contained phrases voiced by a female native Japanese speaker. Each phrase, a segment, indicated by slashes in the examples was recorded in isolation, and the files were trimmed to the shortest possible length. These files were combined to make sentences, where prosodic cues such as pause and stress were unavailable.

Picture files presented pictures for a speeded picture selection task. A computer screen showed pairs of colored pictures. In the pictures, two personified animals are engaged in a certain action for the reversible pattern. For example, one picture depicts a scene of a dog hitting a pig, and this action is reversed in the other. In the incorrect picture of the non-reversible patterns, either an incorrect agent or an incorrect object was shown in a counter-balanced design. In the correct picture, a correct agent-object pair was shown. On the computer screen, the left picture had a red frame and the right picture had a blue frame, corresponding to the colors of left and right button-switches on the response pad.

Procedure

First, an experimenter ensured that a participant knew the names of animals and foods used in the sentences and pictures using a printed-out version of pictures. If a child did not use the correct names, the experimenter told the child the name and asked her/him to repeat it.[2] Second, the experimenter asked a participant to play sound files by pressing the center button on the response pad. S/he was told to press the button as quickly as possible while listening to understand each segment of a sentence. A sound files played a segment, and when the last segment was finished, a bell indicated that a pair of pictures was on a computer screen. The participant was instructed to press either the left red button or right blue button to indicate which picture matched the meaning of a given sentence. No feedback was provided. The participant was told to press the button as quickly and accurately as possible.

Sixteen experimental sentences and six distractors were presented in a pseudo-randomized order so that the same sentence patterns and/or the same animals/objects could not be presented consecutively.[3] Three distractors were used as practice sentences at the beginning of the task. After the practice, adult participants worked on all sentences at a time, whereas children typically worked on them one by one under the direction of an experimenter. All participants were tested individually in a quiet room. It took approximately 10 min for adults and between 15 and 20 min for children to complete all the required tasks.

Data Analysis

The results of the speeded picture selection task were first examined to calculate the overall comprehension correctness for each participant. Outliers of the reaction times were defined as those exceeding 2.5 standard deviations above or below the participant group's mean per condition, and they were replaced by the boundaries.

The listening times for the segments in the self-paced listening task were calculated only for the experimental sentences comprehended correctly by the participants whose comprehension accuracy met the criterion of 80 % correctness. The listening times per segment were calculated by subtracting the file length from the reaction times. Outliers for the listening

[2] Only a few children could not able to answer the correct names. When they were told the correct animal names, all repeated them easily. This indicates that they knew and understood the animal names in the picture; therefore, these participants were not excluded from the analysis at this point.

[3] A reviewer indicated that the number of distractors was disproportionally smaller than that of experimental sentences. This is true and intentionally arranged for child participants, whose concentrations on the task is limited, and also for direct comparison of children with adults. As the reviewer suggested, I examined whether participants developed strategies as they encountered consecutive trials for the second NP region of all sentence types. No such effect was observed for children. On the other hand, in the adults' performance on SOV-R, OSV-R, and OSV-N, a statistically significant difference among trials was found. Subsequent comparisons revealed some differences in listening times among items, but there was no consistent decrease in listening times for consecutive trials for any sentence patterns.

Table 1 Mean comprehension accuracy (in percent) and reaction times (milliseconds) per condition per group (SDs in parentheses)

	SOV-R	SOV-N	OSV-R	OSV-N
Adults				
Accuracy	96.7 (8.4)	99.2 (4.5)	85.0 (18.9)	99.2 (4.5)
Times	1549 (425)	1123 (283)	1996 (815)	1187 (364)
Children				
Accuracy	85.2 (14.4)	98.9 (5.2)	70.5 (24.6)	98.9 (5.2)
Times	4000 (1981)	2270 (415)	4954 (2075)	2260 (631)

times were defined and treated in the same way as those for the reaction times for picture selection.

Results of the Speeded Picture Selection

Overall, the correct pictures were selected 95.0 % of the time by adults and 85.8 % of the time by children. Four children did not meet the criterion of 80 % correctness. Excluding them from the data (n = 22) gave 88.4 % correctness for the children's mean correct responses. None of the participants failed in comprehending all items in the same sentence types. Table 1 summarizes the two groups' mean comprehension accuracy and the mean reaction times. Only one error was made in each non-reversible pattern (SOV-N and OSV-N) by different participants in both groups, which yielded exactly the same means and standard deviations for these patterns in each group. Descriptive statistics suggests that in both groups, these non-reversible patterns were easier than SOV-R, which is in turn easier than OSV-R. This is also reflected in their reaction times, where children's reaction times were much slower than adults'.

Separate repeated-measures ANOVAs with word order (SOV/OSV) and reversibility (reversible/non-reversible) as within-subjects factors were performed for comprehension accuracy and reaction times for each group. The analysis of the comprehension accuracy in adult participants reveals interaction between word order and reversibility, $F(1, 29) = 8.074$, $p < .01$, as well as significant main effects of both word order, $F(1, 29) = 8.074$, $p < .01$, and reversibility, $F(1, 29) = 18.710$, $p < .001$. Subsequent analysis with a simple main effect of word order indicates that mean accuracy rates for OSV were significantly lower than those for SOV in the reversible patterns, $F(1, 29) = 8.826$, $p < .01$, but not in the non-reversible patterns, $F(1, 29) = .000$, $p = 1.0$. Also, a simple main effect of reversibility suggests that mean accuracy rates for reversible sentences were significantly lower than those for non-reversible sentences in OSV, $F(1, 29) = 16.086$, $p < .001$, but not in SOV, $F(1, 29) = 1.851$, $p = .184$. As for the reaction times by adult participants, there was also interaction between word order and reversibility, $F(1, 29) = 11.093$, $p < .01$, as well as significant main effects of both word order, $F(1, 29) = 14.944$, $p < .01$, and reversibility, $F(1, 29) = 61.612$, $p < .001$. Subsequent analysis with a simple main effect of word order shows that mean reaction times for OSV sentences were significantly slower than those for SOV for the reversible patterns, $F(1, 29) = 14.287$, $p < .01$, but not for the non-reversible patterns, $F(1, 29) = 3.171$, $p = .085$. A simple main effect of reversibility indicates that mean reaction times for reversible sentences were significantly slower than those for non-reversible sentences in both SOV, $F(1, 29) = 79.643$, $p < .001$, and OSV sentences, $F(1, 29) = 39.282$, $p < .001$.

The results of children's picture selection disclose, for the comprehension accuracy, main effects of both word order ($F(1, 21) = 4.842$, $p < .05$) and reversibility ($F(1, 21) = 48.810$, $p < .001$). This indicates that the mean accuracy rates for OSV were significantly lower than those for SOV and that the mean accuracy rates for reversible sentences were significantly lower than those for non-reversible sentences. The interaction effect of word order and reversibility approached the significance, $F(1, 21) = 3.904$, $p = .061$. Children's reaction times reveal interaction between word order and reversibility, $F(1, 21) = 13.161$, $p < .01$, as well as the main effects of both word order, $F(1, 21) = 4.905$, $p < .05$, and reversibility, $F(1, 21) = 132.387$, $p < .001$. Subsequent analysis with a simple main effect of word order shows that the mean reaction times for OSV sentences were significantly slower than those for SOV in the reversible patterns, $F(1, 21) = 8.395$, $p < .01$, but not in the non-reversible patterns, $F(1, 21) = .534$, $p = .473$. A simple main effect of reversibility indicates that mean reaction times for reversible sentences were significantly slower than those for non-reversible sentences in both SOV, $F(1, 21) = 83.729$, $p < .001$, and OSV sentences, $F(1, 21) = 103.424$, $p < .001$.

In order to examine the relationship between comprehension accuracy and reaction times, I performed correlation analysis between participants' accuracy rates and their mean reaction times for each sentence pattern in each group. Only a weak negative correlation was found for adults' accuracy rates on SOVR and its reaction times, $r = -.370$, $p < .05$, reflecting that the 4 participants who made errors on SOV-R had rather slow reaction times (means = 1943 ms). All other patterns by adults and children were not statistically significant ($p > .05$).

Results of the Self-Paced Listening

The mean listening times for each segment are shown in Figs. 1 and 2 for adults and children, respectively. Only relevant regions to the current analysis are shown: the first NP indicates the first argument, and the second NP indicates the second argument of each sentence pattern.

The first NPs differ in case markers between SOV and OSV and argument animacy between reversible and non-reversible sentences. For adults' listening times, a repeated-measures ANOVA with sentence type (SOV-R/SOV-N/OSV-R/OSV-N) as a within-subjects factor shows no significant main effect, $F(3, 29) = 1.568$, $p = .203$. On the other hand,

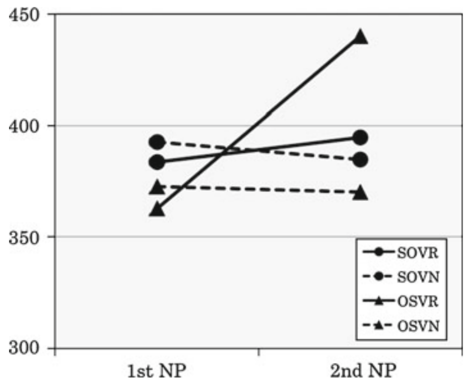

Fig. 1 Listening times by adults

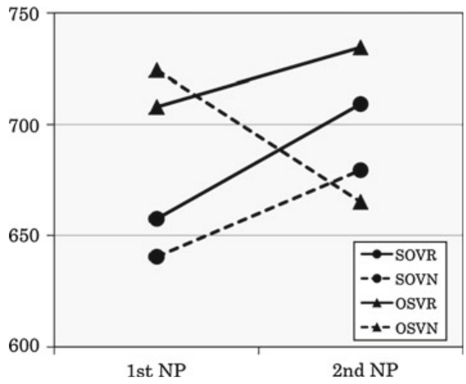

Fig. 2 Listening times by children

for children's listening times, a main effect of sentence type was significant, $F(3, 21) = 3.132$, $p < .05$. Since there was no statistically significant difference between the nominative-marked NPs in SOV-R and SOV-N, $t(21) = 1.016$, $p = .321$, or between the accusative-marked NPs in OSV-R and OSV-N, $t(21) = -.491$, $p = .629$, each word-order pattern was collapsed into one, and the first NPs with different case markers were compared. The results show that listening times in the accusative-marked NP were significantly longer than those in the nominative-marked NP ($t(21) = -2.326$, $p < .05$). However, adults' listening times in the first NP region revealed no such difference ($t(29) = 1.635$, $p = .113$), using the same analysis as for the children's listening times.

Concerning adults' listening to the second NPs, a repeated-measures ANOVA with word order (SOV/OSV) and reversibility (reversible/non-reversible) as within-subjects factors reveal significant interaction between the two factors, $F(1, 29) = 6.628$, $p < .05$, as well as a significant main effect of reversibility, $F(1, 29) = 10.721$, $p < .01$. A simple main effect of word order was significant for the reversible sentences, $F(1, 29) = 7.089$, $p < .05$, but not for the non-reversible sentences, $F(1, 29) = 1.385$, $p = .249$. Also, a simple main effect of reversibility was significant for the OSV sentences, $F(1, 29) = 14.441$, $p < .01$, but not for the SOV sentences, $F(1, 29) = .430$, $p = .517$. These results suggest that the combination of OSV order and reversibility increases listening times in the second NPs for adults. For children, a main effect of reversibility was significant, $F(1, 21) = 6.342$, $p < .05$, as the reversible sentences took longer to listen to than the non-reversible sentences. There was no significant main effect of word order, $F(1, 21) = .060$, $p = .808$, or the interaction between the two factors, $F(1, 21) = .825$, $p = .374$.

Discussion

Interpretations of Scrambled Sentences

The results of a speeded picture selection task indicate that the accuracy order of the four sentence patterns is the same for adults and children (from easier to harder: SOV-N = OSV-N > SOV-R > OSV-R). The OSV order was difficult when provided as a reversible sentence. Under time pressure, even adult native Japanese speakers misjudged (85.0 % correctness). On the other hand, the low OSV-R accuracy rates by children (70.5 % correctness) suggest that they cannot consistently use a case-marking cue for the scrambled sentences, which is compatible with the previous off-line studies. This does not necessarily mean that the grammatical knowledge of case markers is lacking in the grammar of preschool children, but children were greatly affected by the non-canonical case-marking pattern (i.e., accusative-nominative for the OSV order) and the absence of animacy cue (i.e., reversibility) at a performance level.[4]

Reaction times for picture selection also reflect the degree of difficulty. The order of the judgment speed for the four sentence patterns is parallel in both adults and children (from faster to slower: SOV-N = OSV-N > SOV-R > OSV-R), whereas overall reaction times by children were much slower than those of adults. This order corresponds to the accuracy order. Thus, in general, the more difficult the sentence comprehension, the slower the listeners' judgment becomes. Then, does the comprehension accuracy increase with longer judgment times? As there was no positive correlation between accuracy rates and reaction times, there is no speed-accuracy trade-off effect on any patterns in adults' and children's performance.

Processing of Scrambled Sentences

The critical region for the listening-time analysis is the second NP. The effect of a filler-gap dependency should be observed in this region because the gap of the fronted object to be reactivated exists here. The effect of reversibility should also become evident in this region, because a listener recognizes whether the sentence is reversible when they hear the second NP.

Adult listeners spent more time in listening to this region for OSV than for SOV. However, this is true only when the sentence is reversible. These results are consistent with the previous study that examined scrambling in the simple transitive construction (Mazuka et al. 2002), but the present study has revealed that reversibility contributes to the difficulty of processing scrambled sentences and that a filler-gap dependency alone does not delay processing speed in this region of the simple scrambled sentence. For children, increased listening times in the second NP were not observed in the scrambled sentences as compared with the canonical ones. Reversibility is the sole factor that slows processing the second NP. In both children's and adults' processing of the simple transitive construction, the reversibility has robust independent effects.

These results disclose both a similarity and a difference between children and adults in their sentence processing. Most importantly, the similarity is that the sentence processing mechanism employed by Japanese-speaking preschool children is basically the same as adults'. Both children's and adults' computation and interpretation of sentences are incremental in nature. If children had waited for a verb to interpret argument NPs, they would not have had longer listening times for the second NP of the reversible patterns than for the same region of the non-reversible ones. The effect of reversibility in the second NP suggests that children surely start analyzing incoming fragments of a sentence to build a syntactic structure. On the other hand, adults and children differ in the lack of cost associated with a filler-gap depen-

[4] A reviewer suggested that the results should be interpreted in terms of the Competition Model (Bates and MacWhinney 1987, 1989) as the factors considered in this study are consistent with the basic ideas of linguistic cues in this model. In this light, the present study tested three cues: case marking, word order, and reversibility, the last of which is determined by word order and animacy on argument NPs. Generally speaking, these cues all exist in the spontaneous speech of Japanese, but calculating the cue validity, which is the product of cue availability (i.e., frequency) and cue reliability (i.e., consistency) (Kempe and MacWhinney 1998), requires detailed analysis of these cues' properties and the actual data. Therefore, I would like to keep the analysis in light of the Competition Model beyond the scope of this study.

dency in children's listening times. The incremental processing predicted that the children as well as adults slow down at the gap position due to the reactivation of the dislocated constituent, but this was observed only for adults. Why and how do children process scrambled sentences differently? I discuss three plausible accounts that can be considered.

Parsing Strategies, Working Memory, and Case Markers

Probably the most straightforward account of the child/adult difference in a filler-gap dependency is that children and adults have different parsing strategies that lead them to different syntactic representations of scrambled sentences. Unlike adults, children build up gapless scrambled sentences; therefore, no effect of a filler-gap dependency was observed. However, this possibility faces both logical and empirical problems. Logically, having a different syntactic representation suggests yielding a different sentence interpretation, but both children and adults have the same correct interpretations of scrambled sentences, as we consider the listening times based only on correct trials. The children under consideration must have built up the same syntactic structures as the adults. Empirical evidence also supports the same syntactic structures held by children and adults. An off-line study by Suzuki and Yoshinaga (2004) demonstrates that 5- and 6-year-old Japanese-speaking children do parse a gap in scrambled sentences. They investigated children's interpretations of non-reversible OSV sentences that involved a floating quantifier associated with the direct object: OSQV structure.[5] In order to correctly associate the floating quantifier with the fronted direct object, children must refer to the gap posited between S and Q. They found that most children correctly interpreted the quantifier as referring to the direct object and rarely associated it with the subject.

Another counterevidence is available from the on-line studies of English relative clauses. As explained above, both Love (2007) and Roberts et al. (2007) observed the effects of a filler-gap dependency in the comprehension of relative clauses by English-speaking children with similar ages as those in the current study. Although there are differences in target structures, target languages, and experimental methods between these studies and the present experiment, assuming that a filler-gap dependency is a universal property of language, I believe that the effect of a filler-gap dependency, if available, should be observed in any relevant structures, regardless of language.

The second plausible account is that the absence of the effect is due to children's limited working memory capacity. Investigating the processing of relative clauses in English, Roberts et al. (2007) reported that antecedent priming at the gap position was observed only in children and adults with a high working memory span, which is similar to the results obtained from Japanese long-distance scrambling in adults (Nakano et al. 2002). Does this effect based on working memory account for the children's performance in the current study? This is probably not the case, because the distance between the filler and gap in the OSV sentences is very short in the present experiment. Only a subject intervenes the filler and the gap, as in (12), and it is very unlikely that children's working memory span is too low to deal with this distance.

(12) Kinoo / kooen-de / buta-o / inu-ga _____ / osimasita./
yesterday park-Loc pig-Acc dog-Nom push
'Yesterday in a park a dog pushed a pig.'

[5] Q refers to a floating quantifier. Assuming that the direct object moves to the sentence-initial position, Miyagawa (1989, p. 30) suggests that the floating quantifier and the gap must c-command each other (i.e., the mutual c-command requirement).

Conversely, the distance might be too short. Because the sentence is too easy to process, the self-paced listening method might have failed in observing the effect of a filler-gap dependency. Miyamoto and Takahashi (2004) reported the distance effect of a filler-gap dependency in their self-paced reading task examining adult speakers' comprehension of Japanese scrambling. They observed that the farther the distance, the longer it took for them to process (see also, Gibson 1998; Just and Carpenter 1992). However, this does not suggest that a filler-gap dependency has no effect with a short distance between the filler and gap. If the distance in (12) was too short for the experimental method to detect, it is impossible to explain why this effect was observed in adults' performance. Thus, the account based on working memory is not plausible for the present study.

The third account, which is most promising, is that children's processing of case markers affects their listening times. In examining the effect of a filler-gap dependency by comparing OSV with SOV, comparing the different case-marked NPs is inevitable. I have predicted children's processing difficulties in the accusative case marker as compared with the nominative case marker. If the accusative case is processed too slowly, we could not observe the effect of a filler-gap dependency in the second NP region of OSV. The listening times in the first NP region revealed that children's processing of the nominative and accusative case markers are not equally easy or difficult: more time-consuming accusative -*o* is more difficult to process than nominative -*ga* for children. The increased listening times for the accusative case should thus also have an effect in the second NP region, which may cancel the effect of a filler-gap dependency.

Assuming that individual differences exist among children of the target ages in this study, we may find the children who use the case-marking cue just like adult participants. For the purpose of this study, we must identify those who could make good use of a case-marking cue for sentence comprehension and have no asymmetry in processing between the nominative and accusative case markers to explore the effect of a filler-gap dependency. Two indices are considered here: one based on comprehension accuracy and the other on listening times in the first NP.

For comprehension accuracy, the results of the speeded picture selection task are informative. In this task, twelve children scored 3 or above (out of 4) on each pattern and the mean correct scores were 3.5 or above (85 % correct). I analyzed these children's listening times in the second NPs in the same way as in the main analysis. However, the effect of word order and its interaction with the reversibility was not statistically significant.[6] The other analysis, using the listening times of the first NP region, identifies the children who processed the nominative and accusative case markers equally fast. For this purpose, I excluded from the data the children whose difference in the listening times between the nominative-marked NP and accusative-marked NP exceeded 1.5 standard deviations above or below the participant group's mean. The children whose mean listening times in the first NP region exceeded the overall mean listening times per segment (724 ms) were also excluded. The analysis thus included thirteen children with listening times of the second NP, and this yielded a statistically significant interaction effect between word order and reversibility.[7] These results are consistent with those of adult participants, suggesting that the effect of a filler-gap dependency

6 The results of a two-way repeated measures ANOVA show no significant effect of word order ($F(1, 11) = .283$, $p = .605$), and its interaction with the reversibility ($F(1, 11) = .196$, $p = .667$)

7 The results of a two-way repeated measures ANOVA indicate the interaction effect: $F(1, 12) = 4.855$, $p < .05$. A simple main effect of word order was significant for the reversible sentences, $F(1, 12) = 7.329$, $p < .05$, but not for the non-reversible sentences, $F(1, 12) = .750$, $p = .403$. A simple main effect of reversibility was significant for the OSV sentences, $F(1, 12) = 5.084$, $p < .05$, but not for the SOV sentences, $F(1, 12) = .674$, $p = .428$.

is present in this group of children. Therefore, the children's scrambled sentence processing is essentially the same as adults' not only in incremental processing, but also a filler-gap dependency.

Conclusion

Using a combination of self-paced listening and speeded picture selection tasks, this study has presented some discoveries. Regarding adults' parsing of scrambling, we have confirmed the effect of a filler-gap dependency. This study has also found that reversibility contributes to the difficulty of comprehending scrambled sentences. The interaction of these two factors delays listening times in the gap position of the simple OSV structure. On the other hand, the effect of a filler-gap dependency was not observed in the children's overall performance. However, this does not indicate that children's parsing is fundamentally different from that of adults. For those children processed the nominative and accusative case markers equally fast, the reactivation of the dislocated constituent was observed in the gap position, suggesting that children's processing is basically the same as adults'. Although there is a language-particular factor in the development of case markers, preschool children's parsing is incremental in nature, even in a head-final language like Japanese.

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Appendix

Two sets (a/b) of experimental sentences

(1a) Kinoo / kooen-de / inu-ga / buta-o / tatakimasita. / (SOV-R)
yesterday park-Loc dog-Nom pig-Acc hit
'Yesterday in a park a dog hit a pig.'

(1b) Kinoo / kooen-de / tora-ga / kaba-o / tatakimasita. / (SOV-R)
yesterday park-Loc tiger-Nom hippo-Acc hit
'Yesterday in a park a tiger hit a hippo.'

(2a) Kinoo / nohara-de / kitune-ga / panda-o / kerimasita. / (SOV-R)
yesterday field-Loc fox-Nom panda-Acc kicked
'Yesterday in a field a fox kicked a panda.'

(2b) Kinoo / nohara-de / kaeru-ga / nezumi-o / kerimasita. / (SOV-R)
yesterday field-Loc frog-Nom mouse-Acc kicked
'Yesterday in a field a frog kicked a mouse.'

(3a) Kinoo / kawa-de / saru-ga / usi-o / kamimasita. / (SOV-R)
yesterday river-Loc monkey-Nom cow-Acc bit
'Yesterday by a river a monkey bit a cow.'

(3b) Kinoo / kawa-de / usagi-ga / koara-o / kamimasita. / (SOV-R)
yesterday river-Loc rabbit-Nom koala-Acc bit
'Yesterday by a river a rabbit bit a koala.'

(4a) Kinoo / yama-de / hituzi-ga / tanuki-o / osimasita. / (SOV-R)
yesterday mountain-Loc sheep-Nom raccoon-Acc pushed
'Yesterday at a mountain a sheep pushed a raccoon.'

(4b) Kinoo / yama-de / zoo-ga / neko-o / osimasita. / (SOV-R)
yesterday mountain-Loc elephant-Nom cat-Acc pushed
'Yesterday at a mountain an elephant pushed a cat.'

(5a) Kinoo / kooen-de / kitune-ga / itigo-o / tabemasita. / (SOV-N)
yesterday park-Loc fox-Nom strawberry-Acc ate
'Yesterday in a park a fox ate a strawberry.'

(5b) Kinoo / kooen-de / kaeru-ga / tomato-o / tabemasita. / (SOV-N)
yesterday park-Loc frog-Nom tomato-Acc ate
'Yesterday in a park a frog ate a tomato.'

(6a) Kinoo / nohara-de / panda-ga / suika-o / kazirimasita. / (SOV-N)
yesterday field-Loc panda-Nom watermelon-Acc bit
'Yesterday in a field a panda bit a watermelon.'

(6b) Kinoo / nohara-de / nezumi-ga / ringo-o / kazirimasita. / (SOV-N)
yesterday field-Loc mouse-Nom apple-Acc bit
'Yesterday in a field a mouse bit an apple.'

(7a) Kinoo / kawa-de / hituzi-ga / banana-o / sawarimasita. / (SOV-N)
yesterday river-Loc sheep-Nom banana-Acc touched
'Yesterday by a river a sheep touched a banana.'

(7b) Kinoo / kawa-de / usagi-ga / mikan-o / sawarimasita. / (SOV-N)
yesterday river-Loc rabbit-Nom orange-Acc touched
'Yesterday by a river a rabbit touched an orange.'

(8a) Kinoo / yama-de / tanuki-ga / kyuuri-o / namemasita. / (SOV-N)
yesterday mountain-Loc raccoon-Nom cucumber-Acc licked
'Yesterday at a mountain a raccoon licked a cucumber.'

(8b) Kinoo / yama-de / koara-ga / keeki-o / namemasita. / (SOV-N)
yesterday mountain-Loc koala-Nom cake-Acc licked
'Yesterday at a mountain a koala licked a cake.'

(9a) Kinoo / kooen-de / tora-o / kaba-ga / tatakimasita. / (OSV-R)
yesterday park-Loc tiger-Acc hippo-Nom hit
'Yesterday in a park a hippo hit a tiger.'

(9b) Kinoo / kooen-de / inu-o / buta-ga / tatakimasita. / (OSV-R)
yesterday park-Loc dog-Acc pig-Nom hit
'Yesterday in a park a pig hit a dog.'

(10a) Kinoo / nohara-de / kaeru-o / nezumi-ga / kerimasita. / (OSV-R)
yesterday field-Loc frog-Acc mouse-Nom kicked
'Yesterday in a field a mouse kicked a frog.'

(10b) Kinoo / nohara-de / kitune-o / panda-ga / kerimasita. / (OSV-R)
yesterday field-Loc fox-Acc panda-Nom kicked
'Yesterday in a field a panda kicked a fox.'

(11a) Kinoo / kawa-de / usagi-o / koala-ga / kamimasita. / (OSV-R)
yesterday river-Loc rabbit-Acc koala-Nom bit
'Yesterday by a river a koala bit a rabbit.'

(11b) Kinoo / kawa-de / saru-o / usi-ga / kamimasita. / (OSV-R)
yesterday river-Loc monkey-Acc cow-Nom bit
'Yesterday by a river a cow bit a monkey.'

(12a) Kinoo / yama-de / zoo-o / neko-ga / osimasita. / (OSV-R)
yesterday mountain-Loc elephant-Acc cat-Nom pushed
'Yesterday at a mountain a cat pushed an elephant.'
(12b) Kinoo / yama-de / hituzi-o / tanuki-ga / osimasita. / (OSV-R)
yesterday mountain-Loc sheep-Acc raccoon-Nom pushed
'Yesterday at a mountain a raccoon pushed a sheep.'
(13a) Kinoo / kooen-de / tomato-o / kaeru-ga / tabemasita. / (OSV-N)
yesterday park-Loc tomato-Acc frog-Nom ate
'Yesterday in a park a frog ate a tomato.'
(13b) Kinoo / kooen-de / itigo-o / kitune-ga / tabemasita. / (OSV-N)
yesterday park-Loc strawberry-Acc fox-Nom ate
'Yesterday in a park a fox ate a strawberry.'
(14a) Kinoo / nohara-de / ringo-o / nezumi-ga / kazirimasita. / (OSV-N)
yesterday field-Loc apple-Acc mouse-Nom bit
'Yesterday in a field a mouse bit an apple.'
(14b) Kinoo / nohara-de / suika-o / panda-ga / kazirimasita. / (OSV-N)
yesterday field-Loc watermelon-Acc panda-Nom bit
'Yesterday in a field a panda bit a watermelon.'
(15a) Kinoo / kawa-de / mikan-o / usagi-ga / sawarimasita. / (OSV-N)
yesterday river-Loc orange-Acc rabbit-Nom touched
'Yesterday by a river a rabbit touched an orange.'
(15b) Kinoo / kawa-de / banana-o / hituzi-ga / sawarimasita. / (OSV-N)
yesterday river-Loc banana-Acc sheep-Nom touched
'Yesterday by a river a sheep touched a banana.'
(16a) Kinoo / yama-de / keeki-o / koala-ga / namemasita. / (OSV-N)
yesterday mountain-Loc cake-Acc koala-Nom licked
'Yesterday at a mountain a koala licked a cake.'
(16b) Kinoo / yama-de / kyuuri-o / tanuki-ga / namemasita. / (OSV-N)
yesterday mountain-Loc cucumber-Acc raccoon-Nom licked
'Yesterday at a mountain a raccoon licked a cucumber.'

Distractors

(17) Kinoo / mizuumi-ni / panda-ga / imasita. /
yesterday lake-Loc panda-Nom existed
'Yesterday there was a panda by a lake.'
(18) Kinoo / outi-de / tora-to koala-ga / asobimasita. /
yesterday house-Loc tiger-and koala-Nom played
'Yesterday in a house a tiger and a koala played.'
(19) Kinoo / otera-de / nezumi-ga / yane-ni noborimasita. /
yesterday temple-Loc mouse-Nom roof-Loc climbed
'Yesterday at a temple a mouse climbed up on the roof.'
(20) Kinoo / otera-ni / suika-to ringo-ga / arimasita. /
yesterday temple-Loc watermelon-and apple-Nom existed
'Yesterday there were a watermelon and an apple at a temple.'
(21) Kinoo / mizuumi-de / tanuki-to hituzi-ga / kenka-o simasita. /
yesterday lake-Loc raccoon-and sheep-Nom fought
'Yesterday by a lake a raccoon and a sheep fought.'

(22) Kinoo / outi-ni / kyuuri-to banana-ga / arimasita. /
yesterday house-Loc cucumber-and banana-Nom existed
'Yesterday there were a cucumber and a banana in a house.'

References

Avrutin, S., & Wexler, K. (1992). Development of principle B in Russian. *Language Acquisition, 2*, 259–306.

Bates, E., & MacWhinney, B. (1987). Competition, variation, and language learning. In B. MacWhinney (Ed.), *Mechanisms of language acquisition* (pp. 157–193). Hillsdale, New Jersey: Lawrence Erlbaum.

Bates, E., & MacWhinney, B. (1989). Functionalism and the competition model. In B. MacWhinney & E. Bates (Eds.), *The Cross-linguistic study of sentence processing* (pp. 3–73). New York: Cambridge University Press.

Bever, T. G., & McElree, B. (1988). Empty categories access their antecedents during comprehension. *Linguistic Inquiry, 19*, 35–43.

Chomsky, N. (1981). *Lectures on government and binding*. Dordrecht: Foris.

Chomsky, N. (1995). *The minimalist program*. Cambridge, Massachusetts: MIT Press.

Chomsky, N. (1998). *Minimalist inquiries: The framework*, MIT Occasional Papers 15, MITWPL, Cambridge, Massachusetts.

Chujo, K. (1983). The interrelationships among strategies for sentence comprehension. *The Japanese Journal of Psychology, 54*, 250–256 (in Japanese).

Clahsen, H. (2008). Behavioral methods for investigating morphological and syntactic processing in children. In I. Sekerina, E. Fernández, & H. Clahsen (Eds.), *Developmental psycholinguistics: On-line methods in children's language processing* (pp. 1–27). Amsterdam: John Benjamins.

Crain, S., Thornton, R., Boster, C., Conway, L., Lillo-Martin, D., & Woodams, E. (1996). Quantification without qualification. *Language Acquisition, 5*, 83–153.

Crain, S., & Thornton, R. (1998). *Investigations in universal grammar: A guide to experiments on the acquisition of syntax*. Cambridge, Massachusetts: MIT Press.

Conroy, A., Lidz, J., & Musolino, J. (2009). The fleeting isomorphism effect. *Language Acquisition, 16*, 106–117.

Felser, C., & Clahsen, H. (2009). Grammatical processing of spoken language in child and adult language learners. *Journal of Psycholinguistic Research, 38*, 305–319.

Ferreira, F., Henderson, J. M., Anes, M. D., Weeks, P. A., Jr., & McFarlane, D. K. (1996). Effects of lexical frequency and syntactic complexity in spoken-language comprehension: Evidence from the auditory moving-window technique. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22*, 324–335.

Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition, 68*, 1–76.

Gualmini, A. (2004). Some knowledge children don't lack. *Linguistics, 42*, 957–982.

Guasti, M. T. (2004). *Language acquisition: The growth of grammar*. Cambridge, Massachusetts: MIT Press.

Hayashibe, H. (1975). Word order and particles: A developmental study in Japanese. *Descriptive and Applied Linguistics, 8*, 1–18.

Iwatate, S. (1980). The word-order and case strategies in Japanese children. *The Japanese Journal of Psychology, 51*, 233–40 (in Japanese).

Just, M., & Carpenter, P. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99*, 122–149.

Kempe, V., & MacWhinney, B. (1998). The acquisition of case marking by adult learners of Russian and German. *Studies in Second Language Acquisition, 20*, 543–587.

Kuno, S. (1973). *The structure of the Japanese language*. Cambridge, Massachusetts: MIT Press.

Love, T. (2007). The processing of non-canonically ordered constituents in long distance dependencies by pre-school children: A real-time investigation. *Journal of Psycholinguistic Research, 36*, 191–206.

Mazuka, R. (1998). *The development of language processing strategies: A cross-linguistic study between Japanese and english*. Mahwah, New Jersey: Lawrence Erlbaum.

Mazuka, R., Ito, K., & Kondo, T. (2002). Costs of scrambling in Japanese sentence processing. In M. Nakayama (Ed.), *Sentence processing in East Asian languages* (pp. 131–166). California: CSLI Publications.

Miyagawa, S. (1989). *Structure and case marking in Japanese*. San Diego, California: Academic Press.

Miyamoto, E. (2006). Understanding sentences in Japanese bit by bit. *Cognitive Studies, 13*, 247–260.

Miyamoto, E. (2008). Processing sentences in Japanese. In S. Miyagawa & M. Saito (Eds.), *The Oxford handbook of Japanese linguistics* (pp. 217–249). Oxford: Oxford University Press.

Miyamoto, E., & Takahashi, S. (2002a). Antecedent reactivation in the processing of scrambling in Japanese. In T. Ionin, H. Ko, & A. Nevins (Eds.), *Proceedings of HUMIT 2001—MIT and Harvard University annual student conference on language study*, MIT Working Papers in Linguistics 43 (pp. 127–142). Cambridge, Massachusetts.

Miyamoto, E., & Takahashi, S. (2002b). Sources of difficulty in the processing of scrambling in Japanese. In M. Nakayama (Ed.), *Sentence processing in East Asian languages* (pp. 167–188). California: CSLI Publications.

Miyamoto, E., & Takahashi, S. (2004). Filler-gap dependencies in the processing of scrambling in Japanese. *Language and Linguistics 5: Proceedings of the GLOW-Asia-Generative linguistics in the old world conference* (pp. 153–166).

Musolino, J., & Lidz, J. (2006). Why children aren't universally successful with quantification. *Linguistics, 44*, 817–852.

Nakano, Y., Felser, C., & Clahsen, H. (2002). Antecedent priming at trace positions in Japanese long-distance scrambling. *Journal of Psycholinguistic Research, 31*, 531–571.

Nakayama, M. (1995). Scrambling and probe recognition. In R. Mazuka & N. Nagai (Eds.), *Japanese sentence processing* (pp. 257–273). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Nemoto, N. (1999). Scrambling. In N. Tsujimura (Ed.), *The handbook of Japanese linguistics* (pp. 121–153). Oxford: Blackwell.

Nicol, J. (1993). Reconsidering reactivation. In G. Altmann & R. Shillcock (Eds.), *Cognitive models of speech processing: The second sperlonga meeting* (pp. 321–350). Hove: Lawrence Erlbaum Associates.

Otsu, Y. (1994). Early acquisition of scrambling in Japanese. In T. Hoekstra & B. Schwarts (Eds.), *Acquisition studies in generative grammar* (pp. 253–264). Amsterdam: John Benjamins.

Pritchett, B. (1991). Head position and parsing ambiguity. *Journal of Psycholinguistic Research, 20*, 251–270.

Roberts, L., Marinis, T., Felser, C., & Clahsen, H. (2007). Antecedent priming at trace positions in children's sentence processing. *Journal of Psycholinguistic Research, 36*, 175–188.

Saito, M. (1985). *Some asymmetries in Japanese and their theoretical implications*. Ph.D. dissertation, MIT.

Schaeffer, J. (2000). *The acquisition of direct object scrambling and clitic placement: Syntax and pragmatics*. Amsterdam: John Benjamins.

Sekerina, I. A., Stromswold, K., & Hestvik, A. (2004). How do adults and children process referentially ambiguous pronouns?. *Journal of Child Language Research, 31*, 123–152.

Sekerina, I. A., Fernández, E. M., & Clahsen, H. (2008). *Developmental psycholinguistics: On-line methods in children's language processing*. Amsterdam: John Benjamins.

Shibata, H., Sugiyama, M., Suzuki, M., Kim, J. Gyoba, J., & Koizumi, M. (2006). Analyses of the processing around trace positions in Japanese clause-internal scrambled sentences. *Cognitive Studies, 13*, 301–315 (in Japanese).

Suzuki, T. (2007). The development of Japanese case-markers observed through children's comprehension of single-argument sentences. *Gengo Kenkyu, 132*, 55–76 (in Japanese).

Suzuki, T. (2011). A case-marking cue for filler-gap dependencies in children's relative clauses in Japanese. *Journal of Child Language, 38*, 1084–1095.

Suzuki, T., & Yoshinaga, N. (2004). *Linearity or hierarchy in the child grammar: Data from quantifier floating in Japanese. BUCLD 28* (pp. 597–607). Cascadilla Press, Somerville, Massachusetts.

Tamaoka, K., Sakai, H., Kawahara, J., Miyaoka, Y., Lim, H., & Koizumi, M. (2005). Priority information used for the processing of Japanese sentences: Thematic roles, case particles or grammatical functions?. *Journal of Psycholinguistic Research, 34*, 281–332.

Trueswell, J. C., & Gleitman, L. R. (2007). Learning to parse and its implications for language acquisition. In G. Gaskell (Ed.), *Oxford handbook of psycholinguistics* (pp. 635–656). Oxford: Oxford University Press.

Trueswell, J. C., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition, 73*, 89–134.

Yamashita, H. (1997). The effects of word-order and case marking information on the processing of Japanese. *Journal of Psycholinguistic Research, 26*, 163–188.