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ISSUES IN JAPANESE PSYCHOLINGUISTICS FROM COMPARATIVE PERSPECTIVES

VOLUME 2: INTERACTION BETWEEN LINGUISTIC AND NONLINGUISTIC FACTORS

Edited by Masatoshi Koizumi

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Issues in Japanese Psycholinguistics from Comparative Perspectives

The Mouton-NINJAL Library of Linguistics

Edited by
Yukinori Takubo
Haruo Kubozono
Yo Matsumoto

Volume 6

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In memory of Tsutomu Sakamoto

Series preface

The Mouton-NINJAL Library of Linguistics (MNLL) series is a new collaboration between De Gruyter Mouton and NINJAL (National Institute for Japanese Language and Linguistics), following the successful twelve-volume series *Mouton Handbooks of Japanese Language and Linguistics*. This new series publishes research monographs as well as edited volumes from symposia organized by scholars affiliated with NINJAL. Every symposium is organized around a pressing issue in linguistics. Each volume presents cutting-edge perspectives on topics of central interest in the field. This is the first series of scholarly monographs to publish in English on Japanese and Ryukyuan linguistics and related fields.

NINJAL was first established in 1948 as a comprehensive research organization for Japanese. After a period as an independent administrative agency, it was re-established in 2010 as the sixth organization of the Inter-University Research Institute Corporation “National Institutes for the Humanities”. As an international hub for research on Japanese language, linguistics, and Japanese language education, NINJAL aims to illuminate all aspects of the Japanese and Ryukyuan languages by conducting large-scale collaborative research projects with scholars in Japan and abroad. Moreover, NINJAL also aims to make the outcome of the collaborative research widely accessible to scholars around the world. The MNLL series has been launched to achieve this second goal.

The authors and editors of the volumes in the series are not limited to the scholars who work at NINJAL but include invited professors and other scholars involved in the collaborative research projects. Their common goal is to disseminate their research results widely to scholars around the world.

This is the second volume originating from an international conference jointly held by Tohoku University and NINJAL, featuring a collection of papers on psycholinguistics related to Japanese from comparative perspectives. It aims to bridge the gap between theoretical and psycholinguistic studies in the field, covering language production and comprehension by children, patients with aphasia, individuals with autism spectrum disorder, as well as typically developed adult speakers. It will provide both students and experts with essential information for their research and insights into the current state-of-the-art in their respective subfields.

Yukinori Takubo
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Preface

Issues in Japanese Psycholinguistics from Comparative Perspectives came out of the International Symposium on Issues in Japanese Psycholinguistics from Comparative Perspectives (IJPCP) held online in September 2021. IJPCP consisted of twenty-nine papers in ten sessions over two days. It was jointly organized by the JSPS Grant-in-Aid for Scientific Research (S) Project "Field-Based Cognitive Neuroscientific Study of Word Order in Language and Order of Thinking from the OS Language Perspective" and NINJAL (National Institute for Japanese Language and Linguistics) Collaborative Research Project "Cross-linguistic Studies of Japanese Prosody and Grammar" and cosponsored by the Advanced Institute of Yotta Informatics (AI Yotta), Tohoku University, Japan.

Issues in Japanese Psycholinguistics from Comparative Perspectives is in two volumes: *Cross-Linguistic Studies* (Volume 1) and *Interaction Between Linguistic and Nonlinguistic Factors* (Volume 2). The two volumes combined together include 27 papers that were all presented at the conference except for two papers by Takuya Kubo and Jungho Kim, respectively, who were unable to attend the symposium. All the papers went through peer review, and I would like to thank those who kindly acted as inside or outside reviewers.

In organizing the international symposium and editing the volumes, I received invaluable assistance from numerous people. First and foremost, I am grateful to Yukinori Takubo (former Director-General of NINJAL) and Haruo Kubozono (former Deputy Director-General of NINJAL) for their continuous support that made this project possible. Sachiko Kiyama, Kexin Xiong, Maho Morimoto, Misato Ido, Min Wang, Ge Song, Lega Cheng, and Rei Emura helped organize the conference. Thanks are also due to Michaela Göbels and De Gruyter Mouton for their support. The conference and the editing of the volumes were funded by NINJAL and JSPS KAKENHI Grant Number 19H05589.

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Chapter 1
Japanese Psycholinguistics from Comparative Perspectives: Interaction Between Linguistic and Nonlinguistic Factors

1 Introduction

Issues in Japanese Psycholinguistics from Comparative Perspectives comprises two volumes compiling 27 state-of-the-art articles on Japanese psycholinguistics and related topics. It emphasizes the importance of using comparative perspectives when conducting psycholinguistic research.

Psycholinguistic studies of the Japanese language have contributed greatly to the field from a cross-linguistic perspective. However, the target languages for comparison have been limited. Most research focuses on English and a few other typologically similar languages, which are nominative-accusative and subject-before-object languages, as is Japanese. Thus, many current theories fail to acknowledge the nature of ergative-absolutive or object-before-subject languages and treat the nature of nominative-accusative subject-before-object languages as universal to human language. Therefore, a detailed consideration of the language processing stages of more diverse languages (in addition to familiar languages), relative to Japanese, is essential to clarify the universality and diversity of human language and to correctly situate Japanese among languages worldwide.

Beyond the cross-linguistic approach, other prominent methods of comparison in psycholinguistics include comprehension versus production, prosodic versus syntactic processing, syntactic versus semantic processing, semantic versus pragmatic processing, native speakers versus second language learners, typical development versus development of language by people with autism spectrum disorder, typical versus aphasic language development, language versus action, and language versus memory. Comparative studies have proven to be fruitful in revealing the nature of various components of human cognition and how they interact. Many such approaches are underrepresented in Japanese psycholinguistics.

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The studies reported in the two volumes attempt to bridge these gaps. Using various experimental and computational techniques, they address issues of the universality and diversity of the human language and the nature of the relationship between human cognitive modules. Special reference is made to the mechanisms by which the brain processes and represents languages.

2 Outline of Volume 2

Volume 2 contains 13 papers, all related to interactions between linguistic and non-linguistic factors. In Chapter 2, "High sense of agency versus low sense of agency in event framing in Japanese," Manami Sato, Keiyu Niikuni, and Amy J. Schafer investigate how the language-user-internal factor of "Sense of Agency" (SoA, Moore 2016) influences the language users' framing of action events and selection of perspective, as measured by native speakers' responses to active and passive voice in Japanese. The effects of temporarily manipulating SoA (Experiment 1) and an individual's intrinsic differences in SoA (Experiment 2) were tested using two picture-word verification experiments. The results suggest that physical motion shifts language users' SoA, and SoA affects language users' event framing: high SoA enhances an agent perspective, while low SoA enhances a patient perspective in transitive event comprehension.

Chapters 3 and 4 examine the interaction between linguistic complexity and working memory. In Chapter 3, "Locality-based retrieval effects are dependent on dependency type: A case study of a negative polarity dependency in Japanese," Kentaro Nakatani hypothesizes that the *dependency type* interacts with the use of working memory in processing sentences. Specifically, the author assumes non-thematic dependencies are more prone to activation decay than thematic dependencies—yielding locality effects—because they are often linearly discontinuous. Although the two self-paced reading experiments manipulating the distance between a negative polarity item *sika* and its licenser Neg did not directly support this hypothesis, a significant interaction between the locality effects and participants' comprehension performance was identified in that good readers tended to exhibit stronger locality effects. This finding accords with previous findings by Nicenboim et al. (2016), who reported a correlation between locality effects and working memory capacity.

In Chapter 4, "An EEG analysis of long-distance scrambling in Japanese: Head-direction, reanalysis, and working memory constraints," Shingo Tokimoto and Naoko Tokiomoto examine the processing of the discontinuous dependency in Japanese complex sentences using event-related potentials (ERPs), paying close attention to the head-direction difference between English and Japanese. The authors manipulated a possible syntactic island in Japanese by long-distance scrambling and observed four ERPs: anterior negativity, parietal positivity, occipital negativity, and late parietal positivity. They consistently interpreted these ERPs as manifestations of the additional working memory load, reanalysis, verb-arguments thematic correspondence, and detection of a syntactic anomaly.

The subsequent five chapters commonly address the flexible nature of the human parser. In Chapter 5, "The time course of SOV and OSV sentence processing in Japanese," Katsuo Tamaoka considers five questions that examine the processing mechanism of subject-object-verb (SOV)- and object-subject-verb (OSV)-ordered transitive sentences in the head (verb)-final language of Japanese. (1) Why do OSV-scrambled sentences require more processing time than canonical SOV sentences? (2) Does longer-distance scrambling require longer processing times than shorter-distance scrambling? (3) Are head (verb)-final languages disadvantageous for sentence processing? (4) What function does a finally positioned verb have in sentence processing? (5) How does the nature of topicalization affect sentence processing? The answers to these questions indicate that OSV-scrambled sentences are processed by gap-filling parsing. Although pre-head anticipatory processing functions before a final verb are observed, argument information is also required, especially for a scrambled sentence. Subject-topicalized sentences in the same order as canonical SOV sentences may be interpreted as being in the canonical order. However, object topicalization may involve double movements of scrambling and topicalization, requiring even longer processing time than for a single movement forming an OSV-scrambled order. Given these properties in Japanese, further research into the effects of topicalization should be conducted on a head (verb)-initial language in which the topicalized order does not overlap with either of the aforementioned orders.

In Chapter 6, "Sentence processing cost caused by word order and context: Some considerations regarding the functional significance of P600," Daichi Yasunaga observes how the appearance of the P600 component changes in Japanese subject-object (SO) word order versus object-subject (OS) word order per whether line drawings are given as the context. The experimental results revealed that OS word order has a higher processing cost than SO word order and generates P600. Furthermore, as per the presence of context, there were differences in their scalp distribution and the region (bunsetsu) in which they appeared. It suggests that the P600 is an ERP component that reflects a syntactic processing load and a more general cognitive load.

In Chapter 7, "The adaptive nature of language comprehension," Masataka Yano examines the cognitive mechanisms underlying the adaptation achieved during language comprehension. Yano addresses the following two issues through a series of event-related potential experiments. First, linguistic adaptation is expectation-based. Native speakers of Japanese can adjust their expectations for sentences that lack licit syntactic representation but are predictable. Furthermore, a strong prediction error serves as a trigger for adaptation. These findings rule out the hypothesis that accounts for linguistic adaptation in terms of the residual or baseline activation boosts of previously processed representations. Second, linguistic adaptation is selective and rational. Morphosyntactic and aspectual violations induce adaptive behavior, whereas there was no evidence for adaptation to semantic violations. This rational adaptation in comprehension may indicate an underlying cooperative alignment in language communication.

In Chapter 8, "(Dis)similarities between semantically transparent and lexicalized nominal suffixation in Japanese: An ERP study using a masked priming paradigm," Jun Nakajima and Shinri Ohta investigate the lexical processing of morphologically complex words. The Japanese language has two types of de-adjectival nouns: *-sa* and *-mi* nouns. The former is productive and semantically transparent, while the latter is unproductive and has a lexicalized meaning. In this electroencephalographic study, the authors examine how these nouns are processed in the brain. Using a masked priming paradigm, they demonstrated similarities in priming effects on the N400 and laterality effects on the N170 for *-sa* and *-mi* nouns. They also found dissimilarities between *-sa* and *-mi* nouns: a larger N400 and lower behavioral performance for *-mi* nouns given their lexicalized meaning. Using linear mixed-effects models, they determined that the transition probability from stem to suffix attenuated the N400 in the temporoparietal regions. Moreover, both de-adjectival noun types exhibited significant priming effects in the behavioral data; that is, shorter reaction times and lower error rates under the related condition. The results suggest (dis)similarities in the neural mechanisms for processing two types of de-adjectival nouns in Japanese.

In Chapter 9, "Brain mechanisms for the processing of Japanese subject-marking particles *wa*, *ga*, and *no*," Toshiki Iwabuchi, Satoshi Nambu, Kentaro Nakatani, and Michiru Makuuchi report on two functional magnetic resonance imaging experiments conducted to investigate the brain mechanisms underlying the processing of Japanese subject-marking syntactic particles, *wa*, *ga*, and *no*. Experiment 1 revealed that, relative to the nominative marker *ga*, the topic marker *wa* induced higher activity in cortical regions associated with syntactic structure building. Experiment 2 compared *no*-marked genitive subjects with *ga*-marked nominative subjects. Brain regions related to syntactic reanalysis displayed increased activity for the genitive subjects, which is less frequent than the nominative subjects, but the effect was significant only in the early period of the experiment. These results suggest that distinct Japanese subject-marking particles drive different neural subsystems of syntactic processing.

Chapters 10 and 11 shed light on language use by atypical populations. In Chapter 10, "Pragmatic atypicality of individuals with autism spectrum disorder: Preliminary results of a production study of sentence-final particles in Japanese," Taiga Naoe, Tsukasa Okimura, Toshiki Iwabuchi, Sachiko Kiyama, and Michiru Makuuchi consider the pragmatic atypicality of individuals with autism spectrum disorder (ASD). ASD is a neurodevelopmental disorder exhibiting atypicality in the pragmatic aspects of language. Some case studies reported that individuals with ASD seldom use sentence-final particles (SFPs), which are bound morphemes representing the speaker's attitudes and moods; however, there is a need for more empirical evidence to verify this tendency. The authors compared the use of the SFPs, *-ne* and *-yo*, in the same context between Japanese-speaking adults with ASD and typically developed (TD) adults through an oral discourse completion task. The results revealed that adults with ASD used *-ne* less frequently and *-yo* in inappropriate contexts more frequently than TD adults.

In Chapter 11, "Auditory comprehension of Japanese scrambled sentences by patients with aphasia: An ERP study," Michiyo Kasai, Sachiko Kiyama, Keiyu Niikuni, Shingo Tokimoto, Liya Cheng, Min Wang, Ge Song, Kohei Todate, Hidetoshi Suzuki, Shunji Mugikura, Takashi Ueno, and Masatoshi Koizumi investigate the processing load of Japanese sentences that are semantically reversible with the help of canonical and scrambled word orders in patients with two common types of aphasia: Broca's and Wernicke's aphasia. Like their healthy counterparts, patients with Broca's aphasia revealed an ERP-P600 effect for processing scrambled word order relative to the canonical one. However, patients with Wernicke's aphasia did not exhibit any significant ERP effects. Thus, patients with Broca's aphasia, whose lesions are limited to the frontal regions, can sufficiently analyze case particles to comprehend the complex syntactic structures, whereas those with Wernicke's aphasia, whose lesions extend from the frontal to the temporal lobe, may have a functional disconnection for processing them.

Chapters 12 and 13 present studies on the interaction of children's syntactic processing with information structure and prosodic cues, respectively. In Chapter 12, "Experimental studies on clefts and right dislocations in child Japanese," Kyoko Yamakoshi and Hiroyuki Shimada examine various aspects of children's acquisition of Japanese clefts (JCs) and Japanese right dislocations (JRDs). Although JCs and JRDs have similar non-canonical word orders (e.g., OVS), the first experiment showed that children performed differently between the two cases, indicating that children are aware of the difference between them. The authors suggest that children's good performance with JRDs is based on its information structure (Tomioka 2021), and their poor performance with subject clefts reflects the agent-first strategy (Bever 1970; Hayashibe 1975). The second experiment revealed that children have an adult-like knowledge of the anti-reconstruction property of JCs and the reconstruction property of JRDs. The third experiment established that Japanese-speaking children associate the focus particles *dake/sika* incorrectly in JCs and JRDs as English-speaking children do with “only” in the English language (Crain, Ni, and Conway 1994). Moreover, Japanese children exhibit an SO asymmetry, as found in English children. They argue that children’s incorrect associations in JCs and JRDs were not based on surface linear order but on hierarchical structures after reconstruction.

In Chapter 13, “Developmental changes in the interpretation of an ambiguous structure and an ambiguous prosodic cue in Japanese,” Yuki Hirose and Reiko Mazuka investigate whether adults and children abide by the same processing bias when encountering a global structural ambiguity and whether they share a common understanding of what certain prosodic phenomena signal in resolving the ambiguity. They first examine whether young children exhibit an adult-like processing bias (a local interpretation of a modifier), which supposedly results from an advantage in incremental processing. This problem is worth investigating because young children may not be as efficient as adults at processing continuous input as rapidly as it is received. Their second question concerns how children use prosodic information, particularly in the case of a prosodic signal potentially associated with two different roles; that is, as a signal to syntactic structure and as one indicating contrastive status. Hence, to investigate this issue, they consider one instance of branching ambiguity in Japanese.

Finally, in Chapter 14, “Exceptive constructions in Japanese,” Maria Polinsky, Hisao Kurokami, and Eric Potsdam discuss the syntax and semantics of exceptives in the Japanese language relative to the English language and provides suggestions for future experimental research. Exceptives are constructions that express exclusion, as in “*Everybody laughed except Mary.*” The authors present and analyze the expression of exception in Japanese, formally marked with the postposition *igai.* As a postposition, *igai* combines with a noun phrase, the internal structure of that noun phrase can be quite complex; it can include a nominalized CP. The Japanese language allows for connected and free exceptives, which differ per whether the exception and its associate form a constituent (*yes* for the former and *no* for the latter). Polinsky and her colleagues show that the Japanese free exceptives always include an underlying nominalized CP (sometimes headed by a null nominal head) with elided material. This kind of ellipsis differs from clausal ellipsis in the exceptives in languages such as English, where no nominal or determiner head is attested. The Japanese language adds novel data to the observation that the original constraint on universal quantifiers in the associate of an exceptive is excessively strong.

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Manami Sato, Keiyu Niikuni, and Amy J. Schafer

Chapter 2 High sense of agency versus low sense of agency in event framing in Japanese

1 Introduction

A transitive event (e.g., a boy kicking a man), whether in the actual world or a depiction, can be apprehended in perception and interpreted via language as active (e.g., *kick*) or passive (*be kicked*). Interpreting a depicted event, which involves framing it by identifying the thematic roles of the entities and their animacy features and adopting an agent or patient perspective, occurs within the first few hundred milliseconds of viewing it (Castelhano and Henderson 2007, 2008; Dobel et al. 2007; Hafri, Papafragou, and Trueswell 2013; Zwitserlood et al. 2018). Perspective adoption varies per individual differences, such as the level of empathetic or narrative engagement, and egocentric or allocentric bias (Brunyé et al. 2016; Hartung, Hagoort, and Willems 2017; Vukovic and Williams 2015). However, little attention has been paid to how the internal state of language users may influence language processing; hence, this chapter considers whether the internal factor of a *sense of agency* (SoA) could also be pivotal in event framing during language processing.

Sense of agency can be defined as "the feeling of control over actions and their consequences" (Moore 2016: 1) or "the registration that I am the initiator of my actions" (Synofzik, Vosgerau, and Voss 2013: 1). That is, SoA is induced when one's intentions and actions match (Sidarus et al. 2017). Prior studies have attempted to develop implicit and explicit measures of SoA or focused on considering it theoretically (for a review, see Moore 2016). Haggard, Clark, and Kalogeras (2002) demonstrated that when people voluntarily pressed a key and then heard a tone 250 ms later, they perceived the time interval between action and tone as shorter than its actual duration; however, it was not the case when the action was involuntary (i.e., induced using transcranial magnetic stimulation). This "intentional binding" (IB) effect—intended actions accompanied by an SoA—is now widely used as an implicit measure of SoA (e.g., Demanet et al. 2013; Hascalovitz and

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Obhi 2015; van der Westhuizen et al. 2017). Subsequent studies show that active movements induce stronger IB effects than passive or involuntary ones, indicating that initiating intended actions stimulates or increases SoA (e.g., Borhani, Beck, and Haggard 2017; Engbert, Wohlschläger, and Haggard 2008; Engbert et al. 2007; Farrer, Valentin, and Hupe 2013; Moore, Wegner, and Haggard 2009).

The current chapter investigates how the language-user-internal factor of SoA (Moore 2016) affects the early stages of language comprehension processes, including how action events are conceptually apprehended and subsequently interpreted for sentences using the active versus passive voice under an assumption that perspective is reflected in voice preference. We compare the linguistic behavior of Japanese speakers with different SoA levels, either manipulated (Experiment 1) or intrinsic (Experiment 2).

In Experiment 1, we examine whether involvement in motor activities affects language users' SoA (i.e., manipulated SoA), as manifested in participants' event interpretation and reflected in subsequent reactions to active- versus passive-voice verbs used to describe the event in Japanese. We hypothesize that language comprehenders' access to relational and perspective information regarding depicted characters is sensitive to the language comprehenders' embodied information. If so, their motion engagement before viewing a picture should influence their understanding or interpretation of the depicted event. This hypothesis is derived from previous studies showing a tight link between motor activities and language comprehension. For instance, Glenberg, Sato, and Cattaneo's (2008) participants spent approximately 20 minutes moving beans, one by one, toward or away from their bodies, which affected their subsequent comprehension of sentences describing toward or away motions. Additional support comes from studies demonstrating that stimulus perception influences subsequent motion (Bradley et al. 2001; Eder and Klauer 2007; Imbir 2017). For instance, positive stimuli facilitate the execution of "approach" behaviors, such as pulling motions, while negative stimuli elicit faster "avoidance" behaviors, such as pushing actions, a pattern found for positive and negative words (Chen and Bargh 1999), pictures of spiders (Rinck and Becker 2007), and pleasant and unpleasant pictures (Hillman, Rosengren, and Smith 2004; Saraiva, Schuur, and Bestmann 2013). Though these studies suggest that movement and linguistic processing are conducted by the same or linked systems, whether a single, non-repeated action can immediately affect subsequent event perception and linguistic processes warrants further study.

Experiment 2 uses an IB task (Haggard, Clark, and Kalogeras 2002) to measure participants' intrinsic (unmanipulated) SoA and explores whether differences in intrinsic SoA levels affect event apprehension processes. Relative to people with low SoA, people with high SoA should pay more attention to agents and show an increased interpretation of events from the agents' perspective, facilitating their comprehension of events described in the active (versus passive) voice.

2 Experiment 1

Prior research investigating the link between motion and other behavior tends to utilize repetitive or continuous motion rather than a single or punctuated motion (Glenberg, Sato, and Cattaneo 2008). It raises the question of whether the execution of a simple motion can immediately influence language comprehenders' SoA and flexibly change the subsequent process of conceiving and interpreting an event, and, if so, in what way. This study examines the functional role of physical activity that may influence SoA and the framing of a subsequently encountered transitive event. We employed a 3 x 2 experimental design, where participants experienced pulling, being pulled, or remaining static, and then saw a depiction of a transitive event followed by a written description of the event via active or passive verb forms in Japanese.

2.1 Hypotheses

The two hypotheses are based on a general assumption that motion manipulation affects comprehenders' internal state and subsequent cognitive processes. The first hypothesis is an egocentric-agency account, which posits that event interpretations are motion-specific; that is, the type of motor activity in which language comprehenders are engaged affects their SoA in different ways, with potentially different effects on subsequent event perception. For example, voluntary or self-generated motion (i.e., pulling) in the Pull-Agent condition increases SoA, which conceptually highlights the agent figure, facilitating event interpretation from the perspective of the agent and active language processing (e.g., *kicking*). Involuntary or non-self-generated motion (i.e., being pulled) in the Pull-Patient condition reduces SoA, making the agent figure less prominent, hindering interpretation of the event with active voice, and facilitating passive language processing (e.g., *being kicked*). Without prior physical motion (i.e., the Static condition), a default interpretation of transitive events should emerge, which may reveal an underlying perspective preference, such as a preference for active language. An egocentric-agency account predicts that the Pull-Agent condition will elicit faster processing of active than passive verbs relative to the Pull-Patient and Static conditions, and the Pull-Patient condition will elicit faster processing of passive than active verbs.

The second hypothesis is a general-agency account, which claims that event interpretation is not motion-specific and postulates a more general facilitatory effect of motion on active language processing; that is, SoA will be enhanced whenever intentional actions are detected (e.g., when the participant or experimenter is the agent of a pulling action). In this view, it is the participant's detection of the occurrence of an intentional action, regardless of whether the participant is the agent or patient of that action, that will enhance the participant's SoA, which increases the agent's prominence in the event, thus inducing the participant to take an agent perspective, facilitating an active-voice interpretation. A general-agency account predicts that active verbs will be processed significantly faster than passive ones in Pull-Agent and Pull-Patient conditions, and the effect will be greater than in the Static condition (when no intentional action can be detected).

2.2 Methods

2.2.1 Participants

There were 30 participants (four males and 26 females). All were undergraduate students in Japan (average age: 21.45, SD = 0.62), native speakers of Japanese with normal or corrected-to-normal vision, and right-handed.

2.2.2 Picture materials

We created 24-line drawings of transitive events in which an agent physically acts on a patient. Attention toward characters in scenes has been shown to affect event interpretation patterns, and descriptions of such events allow structural alternations between the active (*tataku* "slap") and passive (*tatakareru* "being slapped") voice in Japanese (Gleitman et al. 2007). For the characters in the pictures, we employed three male and three female figures (i.e., boy, man, elderly man, girl, woman, elderly woman). The characters in each drawing were always two males or two females, and, in half the drawings, the agent of the transitive event was on the right, with the patient on the left. In the other half, the agent was on the left, and the patient, the right. The size of the agent and patient figures was balanced (average 39.95 cm^2 and 39.11 cm^2, respectively; this difference was not significant: t = 0.25, p = .802) to ensure that the image size would not affect participants' perspective preference. Beyond the 24 target stimuli, we created 24 line drawings of transitive events as fillers with the same specifications as the target pictures. An additional 12 pictures of transitive events were created for a practice session.

2.2.3 Verb materials

The experiment used 24 critical verbs, each presented in a counterbalanced fashion in active or passive voice, and 24 filler verbs. The critical verbs described the depicted events and were equally natural in the active (e.g., *keru* "kick") and passive (e.g., *kerareru* "being kicked") voice. The filler items were 12 active- and 12 passive-voice transitive verbs that did not correctly represent the events depicted in the paired pictures. Two of the authors (native Japanese speakers) confirmed that each filler verb was semantically unrelated to the pictured event, and that all critical verbs in active and passive voices appropriately represented the pictured events with which they were paired. Of the 12 transitive verbs (six active and six passive) used for the practice session, half matched the depicted event.

2.2.4 Experimental design

The experiment had a 3 (Motion: Static/Pull-Agent/Pull-Patient) x 2 (Voice: Active/Passive) repeated-measures design. Six experimental lists were created using a condition rotation determined by a Latin-square design such that each participant saw each target picture only once, and no participant saw the same verb more than once.

2.2.5 Procedure

Participants took part in the experiment individually in a quiet room. They sat in front of a computer holding one end of a 15-inch stick with their right hand, while an experimenter, who held the other end of the stick, sat across the table. A partition between the participant and the experimenter prevented them from seeing each other. Each trial started with the screen displaying a yellow star for 4000 ms. As soon as the star appeared on the screen, the participants placed and rested their right hand (still holding the stick) on a star-marked mouse pad, which was placed on the right side of the computer. A fixation cross with either a green or a gray background then appeared at the upper center of the screen for 3000 ms. It appeared at the upper center instead of the middle center to ensure that the location of the participants' gaze was not biased toward either the agent or the patient figure when the fixation cross was replaced by the picture. Participants were instructed to pull the stick when the background was green and to do nothing but remain still when the background was gray. We used colored screens to elicit specific actions to avoid any plausible influence from language-based instruction (e.g., "please pull the stick"). When the background was gray, the participants were sometimes pulled by the experimenter, allowing for the implementation of three types of motion manipulations to create the Pull-Agent, Pull-Patient, and Static conditions. (This implementation links Pull-Agent [Pull-Patient] conditions with a motion toward [away from] the participant's body; see Section 2.3.)

Immediately following the offset of the green or gray screen, a transitive-event picture with a white background appeared in the screen's center for 1000 ms. Immediately after the picture disappeared, a word (verb) appeared in the center of the screen in red characters in the active (e.g., *keru* "kick": Active-Voice condition) or passive (e.g., *kerareru* "be kicked": Passive-Voice condition) voice. Participants decided whether the verb described the pictured event they had just seen and indicated their response as quickly as possible by pressing (on an external keyboard) the "1" key for "yes" and the "2" key for "no." As participants held the stick with their right hand, they pressed the key with their left hand. Target pictures were always paired with a correct description in active or passive form, while filler pictures were always paired with an incorrect, active or passive, semantically unrelated description. Therefore, the expected response for all the target trials was "yes" (the "1" key), regardless of voice (active or passive).

Participants received no instruction regarding the voice variation. Verb verification responses and times between the word onset and the key press were recorded and analyzed as accuracy rates and response times (RT), respectively.

The experiment began with a practice session where the participants received instructions and completed 12 practice trials. The main session comprised 24 critical items (expected to elicit "yes" responses) and 24 filler items (expected to elicit "no" responses), with the trial order randomized. The entire session lasted approximately 20 minutes. All participants gave informed consent before participating and were compensated with a 500-yen gift card (approximately US$5 at the time of testing).

2.3 Results

2.3.1 Data analysis

The RT data from the target trials were analyzed using linear mixed-effects models, with participants and items as random factors (Baayen, Davidson, and Bates 2008). We included Voice (Active/Passive) and Motion (Static/Pull-Agent/Pull-Patient) as fixed effects with interactions between the factors. Voice conditions were deviation-coded, and Motion conditions were treatment-coded, with the Static condition as the reference level. We included an additional main predictor (Position: the position of the item in the sequence seen by the participant) in the model, without interactions with Voice and Motion (e.g., Brown, Savova, and Gibson 2012). We conducted backward model comparisons and included random slopes for (primary) fixed factors only if they improved model fit at $p < .20$. The R programming language (R Core Team 2017) and the lmer function within the lmerTest package (Kuznetsova, Brockhoff, and Christensen 2017) were used for the analyses. Before the analyses, target trials in which RT was longer than 3000 ms (0.6% of the target data) were excluded from the data. We also excluded trials in which the participant's response was incorrect. The overall accuracy rate for the task was 98.6%. A logistic mixed-effects model analysis performed on the accuracy data in a similar way to the RT analysis found no significant main effects or significant interaction between Voice and Motion (ps > .50).

2.3.2 Response times

Figure 1 shows the RTs for each condition predicted by the final linear mixed-effects regression model, and Table 1 shows the results of the statistical analysis. The linear mixed-effects model analysis shows that the interaction of Voice and Pull-Agent-Motion ($p = .036$) and the interaction of Voice and Pull-Patient-Motion ($p = .026$) were significant. In both cases, the interaction effect coincided with shorter RTs for active-voice verbs, a pattern inconsistent with an egocentric-agency account and consistent with a general-agency account. There was also a significant effect of Position, indicating that RTs tended to become shorter as the experiment progressed. The results do not support the prediction of a preference for active over passive verb forms in the Static condition. A follow-up analysis for the interactions revealed that simple effects of Voice were significant in the Pull-Agent condition ($\beta = 69.13$, $SE = 24.37$, $t = 2.84$, $p = .005$) and Pull-Patient condition ($\beta = 73.21$, $SE = 24.39$, $t = 3.00$, $p = .003$) but not in the Static condition ($\beta = 0.78$, $SE = 24.55$, $t = 0.03$, $p = .975$).

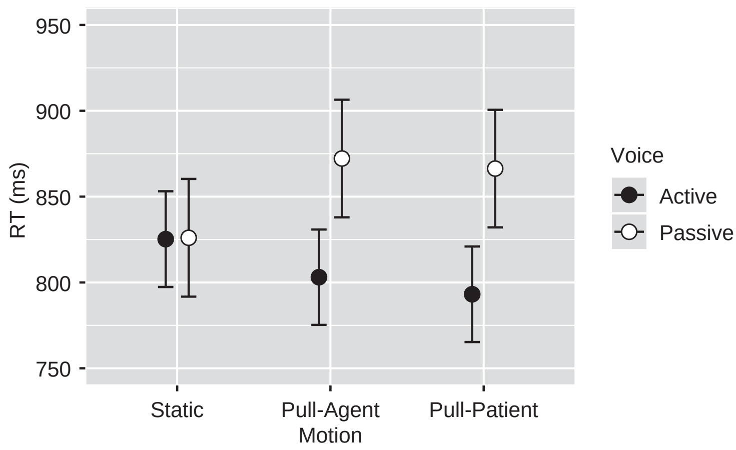

Figure 1: Predicted response times (in milliseconds) for each Motion and Voice condition. Error bars denote ±*SE*s.

Table 1: Results of the linear mixed-effects model analysis for response times.

	β	*SE*	*t*	*p*
Intercept	**825.08**	**28.74**	**28.71**	**< .001**
Voice	0.78	24.55	0.03	.975
Pull-Agent-Motion	12.00	16.25	0.74	.461
Pull-Patient-Motion	4.10	16.27	0.25	.801
Voice × Pull-Agent-Motion	**68.36**	**32.50**	**2.10**	**.036**
Voice × Pull-Patient-Motion	**72.43**	**32.55**	**2.23**	**.026**
Position	**–34.32**	**6.90**	**–4.97**	**< .001**

2.4 Discussion

This experiment explored whether an SoA generated by physical motion could predict language users' selection of perspective in interpreting a transitive event. The finding of comparable RTs for the two pulling conditions is compatible with the general-agency account. That is, intentional pulling actions performed by the participant or experimenter created measurable differences in preferences for agent perspective adoption. Importantly, this advantage for the agent perspective in event interpretation was observed regardless of motion type, indicating that it was not the participants' intention, but their detection of intention, that induced enhanced SoA.

Contrary to the general assumption that active forms are processed faster than passive forms, we found no RT difference between active and passive forms in the Static condition. There are two plausible explanations. First, the experiment presented isolated verbs (with no explicit subject), which might not elicit a general perspective preference in interpreting transitive events. This explanation is compatible with prior findings that Japanese language comprehenders do not have a default perspective in representing a described event when no grammatical pronoun explicitly specifies the perspective (Sato and Bergen 2013). Second, the Static condition, which was supposed to show any underlying preference, may have worked instead as a restricted condition, forcing participants to restrict their motions in a third of the trials, which could have reduced their SoA, facilitating a patient perspective in event interpretation and boosting the passive preference in language processing.

The interpretation of the observed results is, however, complicated by the fact that volition and motion directionality were involved, as the two experimental conditions induced hand movements in opposite directions: participants always pulled the stick in the Pull-Agent condition, while the stick was always pulled by the experimenter in the Pull-Patient condition. The simplest interpretation of the results is that neither volition nor motion directionality affects the perspective from which language comprehenders perceive an event, but detecting intentional actions (regardless of directionality) does.[1] In this interpretation, motion itself, regardless of volition, will increase the likelihood that a participant will take the agent's perspective, relative to a situation without motion. With either type of motion, the motor information that the body experiences or detects is internally activated and enhances one's SoA, inducing the framing of a subsequently encountered event from the perspective of the agent. If either directionality or volition is a crucial factor in perspective adoption when a person is perceiving an event, the Pull-Agent (i.e., the voluntary motion of the hand toward the body) and the Pull-Patient (i.e., the involuntary motion of the hand away from the body) conditions would be expected to produce different patterns of effects on the RTs for the target words. However, these two motion conditions showed the same pattern (i.e., faster RTs for active than passive verbs relative to the no-motion condition). The results suggest that neither volition nor direction of the motion plays a functional role in selecting a

1 Another possible interpretation is that the effect of motion directionality also interacted with the effect of participants' intentionality (i.e., sense of agency), obscuring either factor's independent effects. It is also possible that, motion effects on perspective adoption vary depending on the type of action represented (e.g., an *away* action such as kicking vs. a *toward* action such as holding). We used verbs for four *toward* actions, seven *away* actions, and thirteen *no-direction* actions (e.g., wiping, stepping on). To disentangle their effects, further experiments will need to control directionality independently of intentionality and other factors (e.g., action type).

perspective, but detecting intentional actions stimulates a language comprehender to adopt the agent perspective.

3 Experiment 2

Experiment 1 tested whether and how bodily movements influence SoA, apprehension of transitive events involving two people (i.e., an agent and a patient of an action), subsequent event interpretation, and language processing of the active versus passive voice in Japanese. Experiment 2 investigated whether different levels of intrinsic SoA affect perspective adoption and subsequent linguistic behavior. It had no motion manipulation but, otherwise, replicated Experiment 1. A transitive event was presented on a screen, followed by an active or passive verb, and participants judged whether they matched.

Experiment 2 was inspired by Oren, Friedmann, and Dar (2016), who showed influences of obsessive-compulsive (OC) tendencies on the choice of sentence voice. OC disorder is "marked by intrusive and disturbing thoughts (obsessions) and repetitive behaviors (compulsions) that the person feels driven to perform" (Goodman et al. 2014: 257). The feeling that one's actions are compelled rather than chosen is suggestive of a reduced SoA, and individuals with OC tendencies have been shown to have reduced SoA in research using a common non-linguistic measure (IB), which we adopted for Experiment 2 (Oren, Eitam, and Dar 2019).

While the effects of an intrinsic SoA on the process of perceiving events remain unexplored to the best of our knowledge, Oren, Friedmann, and Dar (2016) suggest the possibility of such effects. In their sentence-production experiment, participants saw a picture of a transitive event (e.g., an elderly woman covers a girl with a blanket) and answered a question (e.g., "Why is the girl happy?"). In general, speakers attend to agents more than patients when perceiving a transitive event (agent-first principle or agent advantage; Cohn and Paczynski 2013; Jackendoff 1992), and speakers generally mention the more activated concept (the agent) earlier in the sentence than the less activated one (the patient), inducing the production of more active constructions than passive ones. Oren, Friedmann, and Dar (2016) find that participants with high OC tendencies were significantly more likely to produce sentences in which the agent of the event was omitted (e.g., "The girl is happy because she has a blanket" rather than "The girl is happy because the *grandmother* is covering her") than a low OC group. The high OC group also tended to produce more passive constructions (e.g., "This is the boy who is being tickled" rather than "This is the boy that the grandfather is tickling") than the low OC group. They concluded that high OC tendencies are correlated with attenuated SoA, indicating that a preference for agent omission and passive constructions reflects reduced SoA (cf. Duranti 2004). That is, people with low SoA seem to have an increased tendency to omit agents and speak in passive constructions when describing events. Therefore, they may be less likely to attend to agents in event perception than people with high SoA.

In this study, after the main experiment, we implicitly measured each participant's intrinsic (i.e., unmanipulated) SoA level with an IB task (Haggard, Clark, and Kalogeras 2002). We hypothesized that SoA level would affect language comprehenders' preferential perception of events. If intrinsic SoA affects the event apprehension process, people with high SoA should be more likely to interpret events from the agent perspective than those with low SoA.

3.1 Method

3.1.1 Participants

A new group of 58 students (undergraduate and graduate) in Japan participated (41 male, 17 female; average age: 20.78, *SD* = 2.23). All were right-handed and native speakers of Japanese with normal or corrected-to-normal hearing and vision.

3.1.2 Picture and verb materials

The experiment used the same picture and verb materials as Experiment 1.

3.1.3 Procedure and intentional binding task

Each participant completed first the main experiment and then the IB task, taking approximately 45 minutes. All participants gave informed consent before participation and received approximately US$10 compensation.

The procedure of the main task was identical to that of Experiment 1, except that Experiment 2 employed no manipulated motion. Each trial started with a 3000 ms fixation cross at the upper center of the screen. The fixation cross was replaced by a transitive-event picture for 1000 ms. Immediately after the picture disappeared, a Japanese verb (in the active or passive voice) appeared at the center of the screen in red characters. Participants were instructed to press the "J" key with their right hand if the word and the picture matched or the "F" key with their left hand if they did not. Target pictures were always paired with a correct description, in either active or passive form, while filler pictures were always paired with an incorrect (active or passive) form.

We measured each participant's intrinsic level of SoA with an IB task (Haggard, Clark, and Kalogeras 2002), adopting van der Westhuizen et al.'s (2017) procedure. The task comprised four experimental blocks: Operant Action (OA), Baseline Action (BA), Operant Effect (OE), and Baseline Effect (BE). The participants experienced the blocks in one of two orders: OA > BA > OE > BE or OE > BE > OA > BA (van der Westhuizen et al. 2017). For each block, the participants received instructions and completed five practice trials and 30 experimental trials.

Figure 2 illustrates the procedure of a trial. At the center of the screen, participants saw a clock face (2.8 cm diameter) on which one hand rotated at a speed of approximately 2500 ms per revolution, starting from a random position. In the OA, BA, and OE blocks, participants were instructed to press the keyboard's spacebar at a time of their choosing. On pressing the key, the clock hand stopped rotating after a random period between 1500 and 2500 ms. In the OA block, a tone (1000 Hz, 100 ms) sounded 250 ms after the key press; in the BA block, no tone sounded. In the OE block, a tone sounded 250 ms after the key press; in the BE block, participants were instructed not to press any key, and the tone occurred 1600–3600 ms (randomly determined) after the clock hand started to rotate. In the OA and BA blocks, participants were asked to report on the position of the clock hand when they pressed the key by entering a number between 1 and 60 on the keyboard. In the OE and BE blocks, participants reported on the position of the clock hand when the tone sounded.

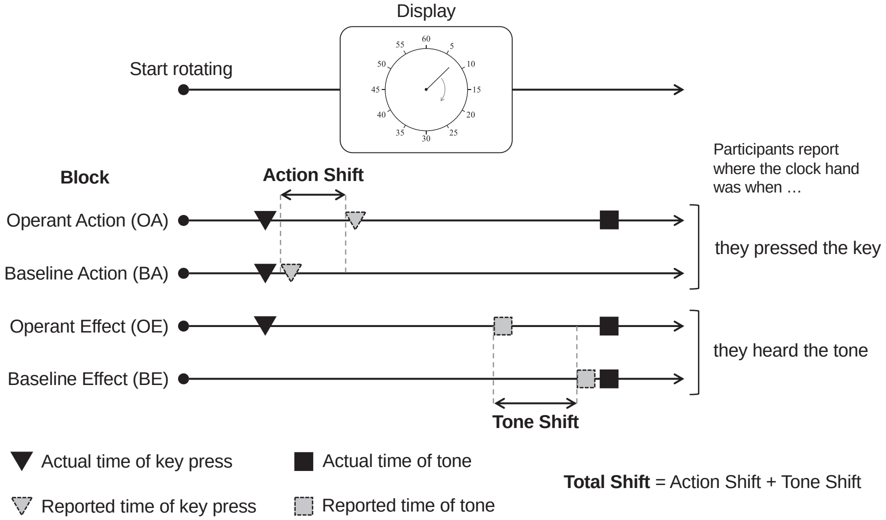

Figure 2: Schematic diagram of the intentional binding task. (Adapted from Niikuni, Nakanishi, and Sugiura, 2022.).

The participants' responses and the times at which the key press or tone occurred were recorded, and the participants' "judgment errors" for each trial were calculated. The judgment error was defined as [time participants reported at the end of the trial] – [actual time at which the key press/tone occurred in the trial]. For example, in the OE or BE block, if the tone occurred when the clock hand pointed at "15" and the participant's response was "11", the error was "–4" (= 11–15). This number was converted to the actual time (in milliseconds).

For each participant, trials in which the judgment error was above or below the block mean by 2.5 *SD* (1.6% of the data) were excluded from the data. We calculated the Total Shift (in msec), defined as the total Action Shift (mean judgment error in OA block – mean judgment error in BA block) and (–1)*Tone Shift (mean judgment error in OE block – mean judgment error in BE block), for each participant. The mean Total Shift for all participants was 144.2 ms (*SD* = 90.4 ms). Corresponding to typical results of IB tasks (see Haggard 2017; Moore and Obhi 2012), the mean Action Shift was positive (32.1 ms, *SD* = 36.8 ms), and the mean Tone Shift was negative (–112.1 ms, *SD* = 81.3 ms). This pattern indicates that when the intentional action (key press) was followed by the consequence (tone), the perceived time of the action was later than when the action was not followed by a consequence (i.e., no tone), whereas the perceived time of the consequence was earlier compared to when it did not follow an action (no key press). Following Haggard's (2017) claim that the degree of shortened time perception between action and outcome (i.e., IB effect) reflects an individual's SoA, we used the Total Shift as a measurement of individual differences in participants' intrinsic SoA.

3.2 Results

3.2.1 Data analysis

First, we excluded target trials in which the participants produced incorrect responses or the RT was longer than 1500 ms (0.8% of the target data).[2] The overall accuracy rate was 97.4%. A logistic mixed-effects model analysis found no significant main effects or significant interaction (*p*s > .25) between Voice and Total Shift (intrinsic SoA). We then analyzed the RT data from the target trials

2 Different cut-off times for data exclusion in Experiment 1 (3000 ms) and 2 (1500 ms) were chosen because overall RTs were slower in Experiment 1, possibly due to the task requiring hand movements. Another possibility for longer RTs in Experiment 1 is that participants used their left hand for yes and no key presses in Experiment 1 while using their right hand to indicate "match" responses in Experiment 2.

using linear mixed-effects models in the same manner as in Experiment 1, with Voice (Active or Passive) as a fixed effect and Total Shift as a continuous predictor. Voice conditions were deviation-coded, and Total Shift values were standardized to *z*-scores.

3.2.2 Response times

Table 2 shows the results of the statistical analysis. Voice ($p < .001$) exhibited a significant main effect in the linear mixed-effects model, indicating that participants reacted faster to the verb in the active- than passive-voice condition. More importantly, the analysis showed a significant interaction between Voice and Total Shift ($p = .009$). As a follow-up analysis for this interaction, we tested the simple effects of Voice for participants with negative versus positive z-scores for Total Shift. This analysis revealed that although participants with relatively low and high SoA reacted significantly faster to active-voice than passive-voice verbs, this tendency was more moderate for participants with low SoA (β = 39.07, SE = 11.32, t = 3.45, p = .001) than high (β = 79.29, SE = 11.51, t = 6.89, $p < .001$). Figure 3 shows the RTs for each condition predicted by the final linear mixed-effects regression model.

We also tested the simple effects of Total Shift for each Voice condition. The analysis revealed that a simple effect of Total Shift was significant in the passive-voice condition (β = 31.92, SE = 14.86, t = 2.15, $p < .036$) but not in the active-voice condition (β = 11.80, SE = 12.40, t = 0.95, p = .345). Participants with relatively low SoA reacted faster to passive-voice verbs than those with high SoA, but this RT difference did not appear for active-voice verbs.

Table 2: Results of the linear mixed-effects model analysis for response times.

	β	*SE*	*t*	*p*
Intercept	**600.94**	**14.44**	**41.63**	**< .001**
Voice	**59.18**	**8.30**	**7.13**	**< .001**
Total Shift	21.86	13.17	1.66	.102
Voice × Total Shift	**20.12**	**7.45**	**2.70**	**.009**
Position	**–7.23**	**3.21**	**–2.25**	**.025**

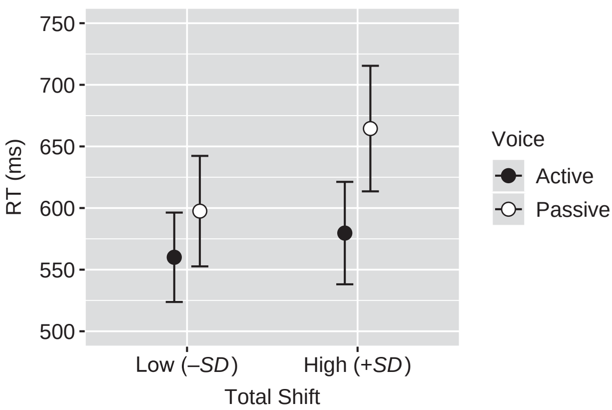

Figure 3: Predicted response times (in milliseconds) for Voice conditions by Total Shift (–*SD*/+*SD*). Error bars denote ±*SE*s.

3.3 Discussion

We asked whether intrinsic SoA as measured by the IB task would elicit different types of perspective adoption (agent vs. patient) in interpreting a transitive event. We hypothesized that if intrinsic SoA affects the event apprehension process, people with high SoA would be more likely to take the agent perspective than those with low SoA. Consistent with the SoA effect on event apprehension, the Voice × Total Shift interaction was significant. Participants with low SoA showed a smaller difference in RTs between the two voice conditions than those with high SoA, who responded faster to active-voice than passive-voice verbs.

Experiment 2 also revealed a significant effect of Voice, with shorter RTs for active-voice verbs. This effect may have stemmed from a strong preference for the agent perspective in transitive-event apprehension (Griffin and Bock 2000; Meyer, Mack, and Thompson 2012) or for unmarked active-voice verbs (relative to inflected passive ones) in word recognition (Yokoyama et al. 2006), leading to active verbs being processed more quickly than passive ones, even in our experimental paradigm.

Furthermore, the results indicated that intrinsic SoA positively predicts RTs for passive-voice verbs but not for active-voice verbs. If our interpretation is correct, SoA would negatively predict RTs for active-voice verbs and positively predict RTs for passive ones. However, without a baseline condition predicted to be equivalent in individuals regardless of SoA, it is challenging to ascertain exactly what accounts for the significant interaction, warranting further investigation.

4 General discussion

Recent studies investigate the role of individual differences in event interpretation (Brunyé et al. 2016; Hartung, Hagoort, and Willems 2017; Vukovic and Williams 2015), and comprehenders' internal status (i.e., SoA) and emotions are known to influence the perception and memory of events (Havas, Glenberg, and Rinck 2007). However, this study is evidently the first to explore the role of a non-linguistic, internal factor, SoA, in event framing and language comprehension. We considered two questions: (i) whether simple physical motions fluidly change the SoA and affect a subsequent process of event interpretation (Experiment 1), and (ii) how individual differences in the intrinsic SoA influence perspective adoption in interpreting a transitive event (Experiment 2).

The results from the two experiments, one with manipulated SoA, and the other, intrinsic SoA, have implications regarding the role of motion in SoA and event interpretation. Experiment 1 supports the hypothesis that motor information (self- or other-generated) that the body experiences is internally detected and enhances the SoA, increasing the prominence of agent figures in events and leading participants to respond to the provided active verbs more quickly, thus reflecting the participants' framing of events from the agent's perspective. The Experiment 1 results accord with the results from the participants with high SoA in Experiment 2, supporting the assumption that the motor manipulations in Experiment 1 enhanced participants' SoA. Moreover, the results from the Static condition in Experiment 1 and the relatively low SoA participants in Experiment 2 suggest that SoA might be significantly lower when motion is hindered than when motion is not manipulated.

This study's participants were native Japanese speakers. How motion influences SoA and subsequent processes of event interpretation may vary across languages. Systematic and consistent ways of describing the world linguistically may play a causal role in cognition, influencing how people apprehend events (Trueswell and Papafragou 2010), pay attention to event participants (e.g., agents and patients; Fausey and Boroditsky 2006; Fausey et al. 2010), remember events (Gentner and Loftus 1979; Loftus and Palmer 1974), and favor explanations of causal attribution (Choi and Nisbett 1998; Choi, Nisbett, and Norenzayan 1999). Such connections would allow for a feedback loop, in which people interpret events in a certain way, influencing descriptions, which then influence subsequent apprehension. English and Japanese, for instance, are useful for comparative purposes as they differ in the frequency of agentive versus non-agentive and transitive versus intransitive expressions. As Choi (2009) observed, Japanese speakers use non-agentive expressions more frequently than English speakers when an event (e.g., dropping keys) equally allows for agentive (e.g., *Kagi-wo otoshita* "[I] dropped [the] keys") and non-agentive (e.g., *Kagi-ga ochita* "[The] keys dropped") descriptions. Fausey et al. (2010) found that although English and Japanese speakers use equally agentive language to describe videos of intentional events (e.g., a person takes an egg from a carton and cracks it against a bowl), Japanese speakers are more likely than English speakers to use non-agentive language when describing accidental events (e.g., a person takes an egg from a carton and drops it so that it breaks). The different linguistic patterns in the two languages manifested beyond language use in the study: both language groups remembered the agents of intentional events equally well, but the English group remembered the agents of accidental events better. This pattern reflects an attenuation of Japanese speakers' attention to the agent in conjunction with their non-agentive linguistic descriptions of the accidental events. The findings indicate that cross-linguistic differences in habitual usage implant different cognitive patterns, which can lead speakers of different languages to focus on different aspects of events. Taking a particular perspective when interpreting an event is not a simple, fixed process; it is shaped by the language people use.

Given that a general cognitive preference can vary across languages depending on various linguistic and extra-linguistic factors, it might be fruitful to examine whether and how languages that exhibit a preference for the agent or patient perspective induce general cognitive differences in terms of SoA. For instance, languages that preferentially use the agent perspective might tune speakers to be self-focused, enhancing SoA in general. Moreover, individual levels of SoA may play a role in speakers' selection of syntactic structures. Within a language, people with relatively high SoA may tend to drop or demote patient arguments and, thus, be more likely to use anti-passives than those with relatively low SoA. However, people with relatively low SoA may tend to include or promote patient arguments.

By examining languages that vary in linguistic properties, we may eventually build a comprehensive model of physical motion and event-encoding processes to better explain the roles of agentivity and embodiment information in our cognition.

5 Conclusion

This chapter compared the linguistic behavior of language comprehenders with different SoA levels, manipulated or intrinsic, when framing or interpreting a transitive event. We predicted that motion would affect the language-user-internal factor of SoA, which could change subsequent cognitive processes, such as apprehending pictured events and internally representing linguistically described events. The findings showed an agent-perspective advantage in event interpretation when participants experienced intentional actions, whether the actor was the participant or an experimenter, but no such agent-perspective advantage when they remained motionless. Therefore, arguably, the detection of intentional action, not volitional action, enhances SoA, increasing agent prominence in transitive events, thus inducing an agent-perspective preference in interpreting such events.

The study also demonstrated the effects of individual differences in intrinsic SoA, which drove the tendency to frame an event in a manner compatible with the active or passive voice; the degree of intrinsic SoA tends to correlate with a preference for active or passive language: people with relatively high SoA are more likely to interpret events from the perspective of an agent and show greater differences in responses to language in the active versus passive voice than those with relatively low SoA.

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Chapter 3
Locality-based retrieval effects are dependent on dependency type: A case study of a negative polarity dependency in Japanese

1 Introduction

The human working memory capacity is limited (Daneman and Carpenter 1980; Just and Carpenter 1992; Osaka and Osaka 1992; Daneman and Merikle 1996; Engle et al. 1999; Conway et al. 2005). For example, the mean reading span score reported by Daneman and Carpenter (1980) (Experiment 1) was 3.15, meaning that, on average, participants were successful in storing and recalling slightly more than three words when a reading task interfered. Moreover, center-embedded structures such as (1a) are more challenging to understand than their right- or left-branching counterparts, such as (1b) (Yngve 1960; Chomsky and Miller 1963); furthermore, double center-embedding easily yields incomprehensible sentences, as illustrated in (2):

(1) a. The reporter who the senator attacked ignored the president.
    b. The senator attacked the reporter who ignored the president.

(2) The reporter who the senator who the congressman criticized attacked ignored the president.

Intuitively, it is obvious that the challenge in the processing of a doubly center-embedded structure stems from the difficulty in keeping track of who does what in the event depicted in the sentence. It is, thus, natural to assume that when multiple grammatical relations must be simultaneously tracked in incremental processing, the memory load will be greater. Such a structural situation is likely to be found

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when two words that constitute some grammatical relationships are separated, with other words intervening between them. The effect incurred by having a long-distance dependency is called a *locality effect* (Gibson 1998, 2000; Van Dyke and Lewis 2003; etc.). Locality effects are assumed to stem from an increase in the memory load because separating two words to be integrated adds to the number of incomplete dependencies that must be stored in memory (Gibson 1998), or it would make it more challenging to retrieve the antecedent at the tail of the dependency chain (Gibson 1998, 2000; Van Dyke and Lewis 2003), or both.

Despite this apparently straightforward logic, the evidence for locality effects has been relatively weak (Bartek et al. 2011; Levy and Keller 2013). Some have reported locality effects, while others have reported anti-locality effects (i.e., speedup effects for having long-distance dependencies). From Table 1, among 17 previous studies on the effects of long-distance dependencies, approximately half reported locality effects, while the rest reported anti-locality effects or null results. Furthermore, anti-locality effects have been found mostly in subject-object-verb (SOV) languages such as Hindi, German, and Japanese. Why is this the case?

Table 1: Summary of previous studies on locality effects (studies with an asterisk did not control for position effects).

	Language	**Dependency type**	**Main findings**
Safavi, Husain, and Vasishth (2016)*	Persian	Thematic	Locality effects
Bartek et al. (2011)*	English	Thematic / RC	Locality effects
Grodner and Gibson (2005)*	English	Thematic / RC	Locality effects
Levy, Fedorenko, and Gibson (2013)*	Russian	RC	Locality effects
Van Dyke and Lewis (2003)*	English	Reanalysis	Locality effects
Vasishth and Drenhaus (2011)	German	RC	Locality effects
Ono and Nakatani (2015)	Japanese	Wh-question	Locality effects
Nakatani (2021)	Japanese	Adverbial NPI	Locality effects
Phillips, Kazaninaa, and Abada (2005)	English	Wh-question	Lower ratings / Delayed P600
Nicenboim et al. (2016)	German, Spanish	RC	Locality effects (high-capacity readers) Anti-locality effects (low-capacity ones)
Vasishth and Lewis (2006)*	Hindi	Thematic / RC	Anti-locality effects
Husain, Vasishth, and Srinivasan. (2014)*	Hindi	RC / Thematic	Anti-locality effects
Konieczny (2000)*	German	Thematic	Anti-locality effects
Konieczny and Döring (2003)	German	Thematic	Anti-locality effects

Table 1 (continued)

	Language	Dependency type	Main findings
Levy and Keller (2013)	German	Thematic RC	Anti-locality effects Locality effects (with an adjunct)
Nakatani and Gibson (2008)*	Japanese	Thematic	Null results (trend toward speedup)
Nakatani and Gibson (2010)	Japanese	Thematic	Null results (slowdown at subject NPs)

(RC: relative clause, NPI: negative polarity item)

One non-trivial factor that may be partially responsible for the mixed results is the lack of control for potential position effects in some of the studies. It has been suggested that placing the critical word in different positions across the conditions would yield a so-called position effect because, generally, people tend to speed up as they proceed through a sentence (Ferreira and Henderson 1993). Thus, simply varying the distance of a dependency by putting more words in between and, thus, pushing the critical word to a later position is likely to facilitate the reading given the differences in the position in which the critical word is placed, independent of dependency length. This confound is often found in prior studies on locality effects (as pointed out by Nakatani and Gibson 2010 and Levy and Keller 2013; see also Table 1). Accordingly, this study's experimental designs employed scrambling operations in Japanese to control for this potential confound.

Another factor worth testing is the effect of dependency type. In SOV languages, the distance between a verb and its arguments, especially the subject, can easily be made greater because the subject is placed sentence-initially in canonical order, the verb is placed sentence-finally, and everything else comes in between. The situation surrounding the dependency length manipulation is different in subject-verb-object (SVO) languages because the verb is placed in the middle of the sentence, and adjuncts are usually placed in the right periphery, a non-interfering position in argument-predicate dependencies. This property seems to have induced the studies of locality effects in SVO languages to resort to the inclusion of extra grammatical dependencies such as a *wh*-gap relationship, where *wh* can be easily placed farther away from its original gap position. Indeed, in SOV languages, dependency length can be manipulated by varying a thematic dependency, whereas in SVO languages, the manipulation of dependency length often requires the inclusion of an extra dependency added to a thematic dependency.

This contrast between SOV and SVO languages may have led to the contrast between the results of the studies of locality effects in SOV and SVO languages. This chapter hypothesizes that argument-predicate (and adjunct-predicate) dependencies (henceforth, *thematic dependencies*) are less prone to memory decay while other extra grammatical dependencies such as *wh*-gap dependencies may be more likely to decay. One possible memory-based explanation for the purported contrast between thematic dependencies and other grammatical dependencies may be provided by activation models, such as the CC READER model (Thibadeau, Just, and Carpenter 1982; King and Just 1991) and Vasishth and Lewis's (2006) activation decay model based on the ACT-R architecture (Anderson et al. 2004 and the references cited therein). According to these theories, information in working memory is assigned some activation level, and it decays from working memory as its activation level decreases. For example, Vasishth and Lewis (2006) hypothesize that the activation level is a function of recency and the number of reactivations triggered by the members of the dependency. The cost of integration at the tail of a dependency is inversely proportional to the activation level of the dependency.

We tentatively adopt Gibson's (2000) dependency integration theory, where dependencies are defined as relations between heads (rather than between a head and a phrase). We assume a head h_1 may trigger an initial expectation for another head ω, in which case an incomplete *dependency chain* $\langle h_1, \omega \rangle$ is set up in working memory; h_1 is the head of the dependency chain, and ω is its tail. If another head h_2 is encountered and is also expected to be integrated with ω, then the dependency chain $\langle h_1, \omega \rangle$ is reactivated and h_2 joins the chain, updating it as $\langle h_1, h_2, \omega \rangle$. If a head that is encountered is then qualified for fulfilling ω, the dependency relations are fully integrated and discharged from working memory. This process is found in a simple case of thematic integrations in SOV language, illustrated below, where the dependency chain dc_1, triggered by the subject *John-ga* with a predicted V head $_V[\ ]$, is stored in working memory and is incrementally joined by (integrated with) the other noun phrases (NPs), reactivated each time, and fully integrated when the verb is encountered:

(3)	dc_1	<***j***, *ω*>		<*j*, ***m***, *ω*>		<*j*, *m*, ***b***, *ω*>		<j, *m*, *b*, **introduced**>
		John	*ga*	*Mary*	*o*	*Bill*	*ni*	*syookaisita*
			NOM		ACC		DAT	introduced

Assumedly, if the ongoing processing of an incomplete dependency chain maintains its activation level in working memory, the members of this dependency chain can be accessed and recalled quickly.

From this perspective, the *wh*-gap dependency offers a different picture. Consider a case of object-extracted relative clauses in English, such as in (4) below.

Here, focusing on the dependencies within the relative clause, two dependency chains are involved: the filler-gap dependency chain triggered by *who* (dc_1) and the thematic dependency triggered by *John* (dc_2). The thematic dependency chain dc_2 is activated until the final participant of the chain, *t*, is set up because all the heads in between integrate into the same dependency chain. However, the filler-gap dc_1 is stored in working memory without “maintenance support” (King and Just 1991: 598) from intervening words, *John* and *criticized*, because they are independent of the A-bar chain formed by *wh* and *t*.

(4)	dc_1		<***wh***, ω_1>	→	→	<*wh*, ***t***>
	dc_2			<***j***, ω_2>	<*j*, **criticized**, ω_3>	<*j*, criticized, ***t***>
		(*the nurse*)	*who*	*John*	*criticized*	*t*

Thus, unlike thematic dependencies, filler-gap dependencies are more likely (if not necessarily) prone to memory decay when the tail of the chain is distanced away from the head. This chapter is primarily concerned with this issue.

2 Negative polarity item dependency with *sika* in Japanese

This study utilizes a novel type of dependency between a negative-sensitive exceptive marker *sika* in Japanese and its obligatory licenser (i.e., verbal negative morpheme Neg), such as in (5) below, to test the hypothesis that locality effects are a function of dependency length and sensitive to the dependency type.

(5)	***tentyoo***	***sika***	*sore*	*o*	{ **sinzi-ta*	/ *sinzi-**nakat**-ta* }
	store-manager	**SIKA**	it	ACC	{ *believe-PAST	/ believe-**NEG**-PAST }
	“Nobody but the store manager believed it.”					

This *sika*-marked element works like English negative polarity items (NPIs) such as *any*, but, unlike English NPIs, it can appear in the subject position of the negated predicate. Furthermore, unlike in English, where Neg precedes an NPI, the licenser Neg in Japanese always follows the *sika*-marked NPI in linear order because Neg in Japanese is a verbal suffix, and Japanese is strictly verb-final. This property makes the NPI-Neg dependency comparable with filler-gap dependencies in that an encounter with the NPI immediately opens a new incomplete dependency, triggering an expectation for Neg.[1]

Several different predictions can be made regarding the processing of a verb whose subject is marked with *sika* relative to the processing of the same verb preceded by a regular nominative-marked subject. First, because *sika* requires Neg, it may strengthen the expectation for the negated verb to come, speeding up the processing when the verb is encountered. However, from a retrieval perspective, adding an extra grammatical dependency may increase the cost of retrieving the *sika*-marked subject. In (5), the thematic relations between the verb root and the nominative and accusative arguments establish an affirmative proposition (*the manager believed it*), whereas the NPI relation between *sika* and Neg triggers an additional inference on exclusivity such that the proposition exclusively applies to *the manager*. These two dependencies should be of distinct types, and, thus, the activation level of the ongoing processing of the *sika*-Neg dependency should decrease in proportion to the distance between *sika* and Neg, under the assumption that the processing of the NPI-Neg dependency would not receive maintenance support from the intervening elements (King and Just 1991; Vasishth and Lewis 2006). This hypothesis predicts some locality effects at the negated verb when the subject is distant and *sika*-marked, relative to the cases where *sika* is not involved or the cases where the subject is local to the verb region. Hence, we conducted two self-paced reading experiments to test these predictions, controlling for the position factor.

3 Experiment 1

The main goal of Experiment 1 was to test the hypothesis that locality effects are a function of dependency length and dependency type, comparing the processing of a verb whose subject was *sika*-marked and that of a verb whose subject was not *sika*-marked.

1 Researchers such as Miyagawa, Nishioka, and Zeijlstra (2016) note that NP-*sika* is unlike NPIs in English in that the former obligatorily requires the presence of the Neg head and cannot be licensed semantically while the latter can be semantically licensed under a non-negative downward-entailing environment (Ladusaw 1979; Von Fintel 1999). They argue that NP-*sika* is better regarded as a negative concord item. Note that NP-*sika* is also different from negative concord expressions in English and other languages, such as *I don't have no money* in that Japanese *sika* obligatorily requires checking by Neg. Given that this study does not address the question of whether the *sika* marked element is a negative concord or polarity item, we tentatively stick to a more traditional term (negative polarity item) when referring to it.

3.1 Methods and materials

Participants

Participants comprised 51 native speakers of Japanese, mostly undergraduate students at a university in Japan. They received 800-yen compensation for their approximately 30-minute participation.

Design and materials

We prepared materials using a 2 × 4 factorial design, varying the Locality factor and the Dependency Type factor. Regarding the Locality factor, the distance was varied by scrambling. The Dependency Type factor was varied by different subject markers: NP *ga* "NP NOM," NP *dake ga* "NP only NOM," or NP *sika*. Neither case marker *ga* nor exclusivity marker *dake* "only" requires a negative context. Thus, only the *sika*-marked subjects were obligatorily negative-sensitive.[2] Note that, semantically speaking, *sika* is similar to *dake* in that both denote exclusivity. The non-negative-sensitive *dake* conditions were added to ascertain whether they were semantic exclusivity or expectation for an obligatory licensing dependency that would induce locality effects. All the target sentences were further embedded as adjunct clauses (using either *node* or *tame*, both of which are suffixal conjunctions heading "because" clauses) to avoid potential wrap-up effects. A sample set of materials is shown below, where regions for presentation are shown by slashes. The Locality factor did not alter the interpretations of the sentences; thus, English translations for the Local conditions are not given. The crucial dependencies in this experimental design are shown in boldface. The matrix clause in which the target clause was embedded is shown in (6a) but omitted in the other conditions for brevity.

2 When an NP is marked with *sika*, nominative and accusative case markers are obligatorily deleted, making the *sika* conditions slightly more ambiguous than others, but we assumed that sentence-initial *sika* phrases would likely be interpreted as subjects because of the canonical SOV order, especially when they referred to humans.

(6) a. Nom × Distant

tentyoo ga / *ueetoresu ga* / *zyoorenkyaku o*
manager NOM / waitress NOM / regular.customer ACC
/ *nagut-ta to* / ***sinzi-nakat-ta*** *node* / *hukutentyoo*
/ hit-PAST COMP / **believe-NEG-PAST** because / assistant.manager
wa / *doo* / *de-tara* / *yoi noka* / kangaeagune-ta.
TOP / how / deal-if / good Q / wonder-PAST
"Because the manager did not believe that the waitress hit the regular customer, the assistant manager wondered how to properly deal with it."

b. Only × Distant

tentyoo dake ga / *ueetoresu ga* / *zyoorenkyaku o*
manager only NOM / waitress NOM / regular.customer ACC
/ *nagut-ta to* / ***sinzi-nakat-ta*** *node* / . . .
/ hit-PAST COMP / **believe-NEG-PAST** because / . . .
"Because only the manager did not believe that the waitress hit the regular customer, . . ."

c. *sika* × Distant

tentyoo sika / *ueetoresu ga* / *zyoorenkyaku o*
manager SIKA / waitress NOM / regular.customer ACC
/ *nagut-ta to* / ***sinzi-nakat-ta*** *node* / . . .
/ hit-PAST COMP / **believe-NEG-PAST** because / . . .
"Because nobody but the manager believed that the waitress hit the regular customer, . . ."

d. Nom × Local

ueetoresu ga / *zyoorenkyaku o* / *nagut-ta to*
waitress NOM / regular.customer ACC / hit-PAST COMP
/ ***tentyoo ga*** / ***sinzi-nakat-ta*** *node* / . . .
/ **manager NOM** / **believe-NEG-PAST** because / . . .

e. Only × Local

ueetoresu ga / *zyoorenkyaku o* / *nagut-ta to*
waitress NOM / regular.customer ACC / hit-PAST COMP
/ ***tentyoo dake ga*** / ***sinzi-nakat-ta*** *node* / . . .
/ **manager only NOM** / **believe-NEG-PAST** because / . . .

f. *sika* × Local

ueetoresu ga / *zyoorenkyaku o* / *nagut-ta to*
waitress NOM / regular.customer ACC / hit-PAST COMP
/ ***tentyoo sika*** / ***sinzi-nakat-ta*** *node* / . . .
/ **manager SIKA** / **believe-NEG-PAST** because / . . .

Note that even though the meaning of *sika* is comparable to that of *dake* in exclusivity, it works in the opposite direction regarding truth conditions because NP *sika*, when properly licensed, creates an affirmative context for the *sika*-marked element (i.e., "nobody but X" is affirmative regarding X). Thus, (6c) means "only the manager believed," whereas (6b) means "only the manager did not believe." Although this study is concerned with the effects of negative polarity dependency and locality, not the effects of negation itself (cf. Yoshida 2002), affirmative versions of the *dake* conditions were also included as another type of grammatical relation for comparison.

(6) g. OnlyAff × Distant

tentyoo dake ga / *ueetoresu ga* / *zyoorenkyaku*
manager only NOM / waitress NOM / regular.customer
o / *nagut-ta to* / ***sinzi-ta*** *node* / . . .
ACC / hit-PAST COMP / **believe-PAST** because / . . .
"Because only the manager believed that the waitress hit the regular customer, . . ."

h. OnlyAff × Local

ueetoresu ga / *zyoorenkyaku o* / *nagut-ta to*
waitress NOM / regular.customer ACC / hit-PAST COMP
/ ***tentyoo dake ga*** / ***sinzi-ta*** *node* / . . .
/ **manager only NOM** / **believe -PAST** because / . . .

The truth-conditional semantics of (6g, h) are comparable to those of (6c, f). These conditions were included to tease apart the effects of the Dependency Type factor and the truth-conditional semantics. In an ideal world, we could have prepared the affirmative conditions for the Only and other conditions, adopting a 2 × 3 × 2 factorial design ({Distant/Local} × {Nom/Only/*sika*} × {Neg/Aff}), though doing so would raise the number of conditions to 12, which is practically challenging to implement. Moreover, the combination of *sika* × Aff is ungrammatical in the first place. Thus, we included the affirmative versions of the Only conditions only, treating them as another level in the Dependency Type factor, labeled OnlyAff. Note that the critical verb region in the OnlyAff conditions lacked a negative morpheme, making this region shorter and less complex than the same region in the other Dependency Types, all of which involved Neg. Therefore, the interaction with the Locality factor would be the only target issue regarding OnlyAff. 32 sets of items as exemplified in (6a–h) were constructed and distributed into eight lists, using a Latin Square design, and 96 filler items were added to each list, among which 54 items were from three unrelated experiments, and 42 were pure fillers unrelated to any of the sub-experiments.

Procedure

The experiment was conducted with Linger 2.94 (https://tedlab.mit.edu/~dr/Linger/), a sentence-processing experimental presentation program written by Douglas Rohde, using Apple Mac mini computers on Mac OS X and 17-inch LCD monitors. The program presented one sentence at a time on the monitor, left to right and region by region in a noncumulative, moving-window manner as a participant pressed the space bar (Just, Carpenter, and Woolley 1982). Each region roughly corresponded to a unit containing one free morpheme plus suffixal-bound morphemes (e.g., case markers, postpositions, and conjunctions). The program presented the materials of one list in a different pseudo-random order for each participant such that no two target items were presented consecutively. The participants were asked to read the sentences as naturally as possible. The experiment was preceded by brief instructions and 10 practice items. Each stimulus sentence was immediately followed by a yes-no question regarding the content of the sentence, with visual feedback for wrong answers.

3.2 Results

Comprehension accuracy

The mean accuracy rate of all items (including fillers and excluding practice items) was 81.2%, and the mean accuracy rate of the target items for this experiment was 79.2%. The breakdown of the mean accuracy rate by conditions was as follows: (6a) Nom × Distant 79.4%; (6b) Only × Distant 76.5%; (6c) *sika* × Distant 71.1%; (6d) Nom × Local 82.8%; (6e) Only × Local 82.8%; (6f) *sika* × Local 77.0%; (6g) OnlyAff × Distant 78.9%; and (6h) OnlyAff × Local 85.3%. Numerically, the mean accuracy rate of the *sika* conditions was lower than that of the others (74.0% vs. 81.0%); that of the Distant conditions was lower than that of the others (76.5% vs. 82.0%); that of the Only conditions was slightly higher than that of the others (80.9% vs. 77.6%); and that of the OnlyAff conditions was higher than that of the others (82.1% vs. 78.3%). The fitted logistic regression model revealed neither the main effects of any of the factors nor significant interactions between them (all ps > .1).

Reading times

Data points beyond three standard deviations (SD) from the relevant condition × region cell mean were discarded to eliminate the outlier effects given noisy factors such as lack of attention and sleepiness. Wrongly answered trials were trimmed for initial analyses.

For statistical analyses, linear mixed effects (LME) models were fitted using the lmerTest package (which depends on lme4) in the statistical software R (version 3.6.2, 2019-12-12). We fitted the models with the Locality and dependency type factors as fixed effects. Deviation coding was used to code the main effects and interactions, with the Nom(inative) conditions and the Local conditions treated as baselines such that we could see, relative to the baselines, the effects of having dependencies with *sika*, *dake* (Only), or *dake* in an affirmative context (OnlyAff) and the effects of having long-distance dependencies (Locality).

We also included the reading times in the pre-critical region as a fixed effect (labeled "spillover") in the models (Vasishth and Lewis 2006) because the words in the region immediately preceding the critical region were not constant between the Local and Distant conditions, whose effects may have spilled over the response times (RTs) in the critical region. The values of this factor were centered and scaled before being built into the models because the values would, otherwise, be too different in scale from the other fixed factors. Though models without this spillover factor eventually showed essentially similar results, we report the results of the models with the spillover factor. Participant and item intercepts were included in the model as random effects, except for the random slopes, as the model had too many factors, and the inclusion of random slopes prevented the model from reaching convergence.

The results from the best-fitting LME model revealed the main effects of *sika* ($t = 1.93$, $p = .054$, with *sika* slower), Only ($t = 4.35$, $p < .001$, with Only slower), and OnlyAff ($t = -7.75$, $p < .001$, with OnlyAff faster) but no interactions (all $|t|$s < 0.6, all ps > .5). However, on dividing the participants into two groups per the comprehension accuracy (CA) rates of the filler items, a different picture emerged. The mean raw RTs for the critical verb region in the data from the upper group ($n = 26$), whose CA rates were equal to or above the median (83.2%), showed a tendency toward an interaction between the Locality and the *sika* factors ($t = 1.87$, $p = .063$) in such a direction that the distance did more harm to the *sika* than nominative conditions, whereas the lower group ($n = 25$) revealed an opposite tendency ($t = -1.79$, $p = .074$). No such effects were found in the comparison between the Nom conditions and the Only or OnlyAff conditions (all $|t|$s < 0.78, all ps > .43). Further, the lower group seems to have read the critical region much faster than the upper group (estimated intercepts: 784.5 [1137.3] ms for the lower [upper] group). Hence, good and poor readers (per the CA rates) may have had different strategies when processing the negative polarity dependencies.

We conducted post hoc analyses of the data including participants' comprehension performances (centered and scaled) on the 96 filler items as a fixed effect in the model to see if this tendency is statistically robust. We fitted an LME model to the data regardless of whether the trials were answered correctly because the data size would, otherwise, be skewed toward those of participants with higher accuracy rates. Table 2 shows a summary of the results from the best-fitting LME model.[3] The analyses showed the main effects of *sika* (t = 3.04, p = .002) and Only (t = 3.57, p < .001) relative to the baseline nominative conditions, showing that these markers incurred extra cost. A main effect of OnlyAff was also found (t = –8.49, p < .001), which is a trivial finding because the verb region of the OnlyAff conditions lacked a negative morpheme. There was a strong main effect of CA rates (t = 5.09, p < .001) such that higher comprehension rates correlated with greater reading times.

Despite no interaction of the Locality factor and the *sika* factor per se, there was a significant three-way interaction of Locality × *sika* × CA (t = 2.29, p = .022). Figure 1 presents a scatter plot of the locality effects (the differences in the log-transformed RTs between the Distant and Local conditions) for the NPI (*sika*) conditions at the critical region, relative to the baseline nominative conditions, overlaid by regression lines for the NPI conditions and the Nom conditions to visually see the interaction trend. Regression analyses showed a positive correlation between locality effects and CA rates for the *sika*-marked conditions (t = 3.20, p = .002, r = .423) but no such correlation for the nominative conditions (t = 0.05, p = .963, r = .007). Figure 2 illustrates the contrast between good and poor readers defined as the upper quartile group (CA rate 85.9% or higher) and the lower quartile (78.4% or lower) under an extreme-groups design (cf. Conway et al. 2005: 782–783) in a visual summary of the mean RTs of all conditions. Statistically, the good readers (n = 13) showed a significant locality effect for *sika* (t = 2.23, p = .027), whereas the poor readers (n = 13) showed no such effect (t = –0.34, p = .733). No other terms reached significance (all ps > .1), except for predicted (and irrelevant) main effects of OnlyAff (ts < –3, ps < .001).

There were also interactions between CA and Locality (t = 2.15, p = .032), suggesting that participants with higher CA rates were more careful in integrating long-distant dependencies, and between CA and *sika* (t = 2.20, p = .028), suggesting that those readers were more sensitive to the presence of the NPI marker and its retrieval. An interaction between CA and OnlyAff, which shows a reverse trend (t = –3.06, p = .002), indicates that the magnitude of the facilitation effect given the absence of the negative morpheme (in the OnlyAff conditions) relative to its presence (in the Nom conditions) was greater when the CA rate was higher, possibly because good readers were more careful when processing negated sentences than poor readers.

3 The model used was as follows: rt ~ Locality + *sika* + Only + OnlyAff + Locality:*sika* + Locality:Only + Locality:OnlyAff + CA + CA:Locality + CA:*sika* + CA:Only + CA:OnlyAff + CA:Locality:*sika* + CA:Locality:Only + CA:Locality:OnlyAff + spillover + (1|subj) + (1|item).

Table 2: Results of linear mixed effects model analysis for Experiment 1.

	Estimate	SE	*t*-value	Pr(>|t|)
(Intercept)	912.1	38.4	23.77	.000 ***
Locality	14.8	13.8	1.07	.285
sika	72.5	23.9	3.04	.002 **
Only	85.6	24.0	3.57	.000 ***
OnlyAff	−202.7	23.9	−8.49	.000 ***
CA	164.0	32.2	5.09	.000 ***
spillover	27.6	14.4	1.92	.055 .
Locality:*sika*	12.1	23.9	0.51	.613
Locality:Only	−13.8	24.0	−0.58	.565
Locality: OnlyAff	12.6	23.9	0.53	.597
Locality:CA	29.9	13.9	2.15	.032 *
sika:CA	53.6	24.4	2.20	.028 *
Only:CA	43.5	24.5	1.78	.076 .
OnlyAff:CA	−74.9	24.5	−3.06	.002 **
Locality:*sika*:CA	55.1	24.1	2.29	.022 *
Locality:Only:CA	−36.6	24.3	−1.51	.132
Locality:OnlyAff:CA	−4.7	24.3	−0.19	.848

Signif. codes: 0 "***" .001 "**" .01 "*" .05 "." 0.1 " " 1

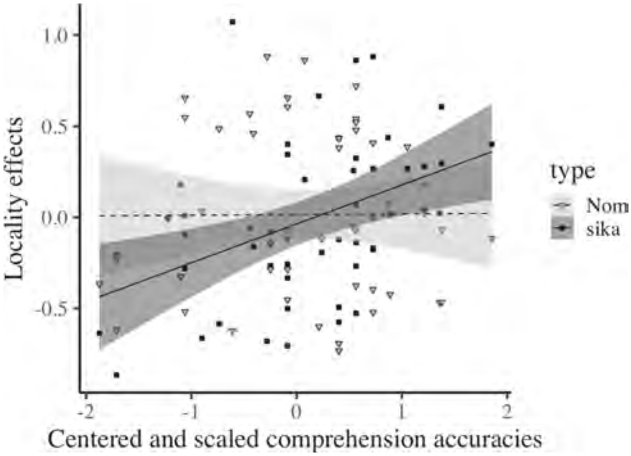

Figure 1: Differences between the log-transformed response times of the Distant conditions and those of the Local conditions at the critical verb region, as a function of centered and scaled comprehension accuracies.

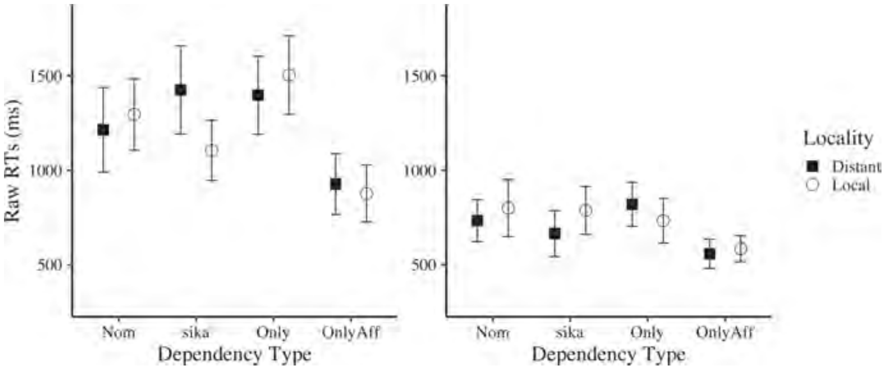

Figure 2: The mean raw response times of the critical region for the good readers (left) and the poor readers (right), with error bars representing 95% confidence intervals.

3.3 Discussion

Although locality effects per se were not found for *sika*, Only, or OnlyAff relative to the baseline nominative conditions, there was an interaction between the locality effects for the *sika*-marked conditions and the participants' CA rates: participants who scored better on comprehension questions showed stronger locality effects. CA rates also showed a strong main effect such that better readers tended to be slower, indicating that better readers were more careful in processing sentences. Further, there were no interactions between CA and Locality effects with the Only or OnlyAff conditions, even though these conditions were semantically comparable to the *sika* conditions. As noted, *dake* "only" does not call for a syntactic licenser. The presence of locality effects for *sika* and their absence for *dake* suggests that it was not the semantic computation of exclusivity but the setup of an extra dependency chain that incurred locality effects.

One might be skeptical about all these conclusions because the results did not reveal straightforward locality effects for *sika*—we only found an interaction between locality effects and CA rates. Under this hypothesis, the processing of *sika* involves two kinds of effects that counter each other: the processing load for retrieving distant *sika* and the facilitation by an expectation for Neg. Thus, locality effects at the critical region would be observed only when the retrieval of the antecedent *sika* is costly enough to override the expectation-based facilitation effect (cf. Levy and Keller 2013). Hence, perhaps, we did not find straightforward locality effects because the distant-based retrieval cost was not large enough. In Experiment 2, we augment the retrieval cost at the critical region by making the distance between NP-*sika* and Neg greater by adding a word. We may detect locality effects across all the participants if the distance-based cost was large enough.

4 Experiment 2

Experiment 2 was essentially identical to Experiment 1, except that the dependency distance in the Distant conditions was made one region greater by adding a locative adjunct to find more robust locality effects.

4.1 Methods and materials

Participants

The participants comprised 77 native speakers of Japanese, mostly undergraduate students at the same university as in Experiment 1. None had participated in Experiment 1. They were paid 800 yen for their participation, which lasted approximately 30 minutes.

Design and materials

We adopted the same design, target and filler materials, and procedures as in Experiment 1, except that a locative adjunct was added to the embedded clause of each target item, making the distance between the subject and the critical verb in the Distant conditions (6a-c, g) greater by one region. For example, the *sika* × Distant condition (6c) was transformed into (7) below, with a locative adjunct (underlined) added immediately after the embedded subject:

(7) *sik*a × Distant

tentyoo	***sika***	/ *ueetoresu*	*ga*	/ *tennai*	*de*	/ *zyoorenkyaku*	*o*
manager	**SIKA**	/ waitress	NOM	/ inside.shop	at	/ regular.customer	ACC

/ *nagut-ta*	*to*	/ ***sinzi-nakat-ta***	*node*	/ . . .
/ hit-PAST	COMP	/ **believe-NEG-PAST**	because	/ . . .

"Because nobody but the manager believed that the waitress hit the regular customer in the restaurant, . . ."

Unlike most English prepositions, Japanese postpositions have no adnominal/adverbial ambiguity; the locative phrases used in this experiment were always unambiguously adverbial. This extra phrase was added in the same position (i.e., immediately after the embedded subject) in all the other seven conditions.

Procedure

The procedure and filler items of Experiment 2 were identical to that of Experiment 1.

4.2 Results

Comprehension accuracy

The mean accuracy rate of all items (including fillers and excluding practice items) was 78.2%, and the mean accuracy rate of the items for this experiment was 74.4%. The breakdown of the mean accuracy rate by conditions was as follows: Nom × Distant 71.8%; Only × Distant 69.5%; *sika* × Distant 66.9%; Nom × Local 75.0%; Only × Local 78.6%; *sika* × Local 75.6%; OnlyAff × Distant 79.9%; and OnlyAff × Local 78.6%. The fitted logistic regression model did not reveal any main effects or interactions (all ps > .2).

Reading times

The statistical analyses for Experiment 2 followed those of Experiment 1. When we analyzed the correctly answered data points (within 3 SDs of the relevant condition × region cell mean) without considering participants' comprehension performances, we found the main effects of Only (t = 2.89, p = .0039, with Only slower), and OnlyAff (t = –7.13, p < .001, with OnlyAff faster) but no main effect of *sika* (t = 1.30, p = .196); there was a weak tendency toward a locality effect with *sika* (t = 1.77, p = .077) but not with Only or OnlyAff ($|t|$s < 1.2, ps > .2). As in Experiment 1, we found a similar contrast between the two groups divided by the CA rates for filler items at the median (79.2%): the upper group (n = 41) showed a locality effect for *sika* (t = 3.17, p = .002), while the lower group (n = 36) showed an opposite tendency (t = –1.70, p = .090). Thus, we re-fitted the model with participants' centered and scaled CA rates and relevant interactions to the data (irrespective of whether they were correctly answered). Table 3 summarizes the results from the best-fitting LME model. The analyses showed main effects of Only (t = 3.00, p = .003), OnlyAff (t = –7.63, p < .001), CA (t = 4.19, p < .001), and spillover (t = 6.70, p < .001). There was also an interaction of CA and OnlyAff (t = –2.79, p = .005).

There was a strong main effect of CA such that participants with higher CA rates were slower at reading the critical region (t = 4.19, p < .001). More importantly, we found a significant three-way interaction of CA × Locality × *sika* (t = 2.60, p = .009). Figure 3 shows the scatter plot of the locality effects for the NPI (*sika*) conditions at the critical region, relative to the baseline nominative conditions. Regression analyses revealed a positive correlation between locality effects and CA for the *sika*-marked conditions (t = 3.96, p < .001, r = .423) but no such correlation for the nominative conditions (t = 0.50, p = .619, r = .059). As for good and poor readers defined as the upper (CA rate 84.4% or higher) and lower (75.8% or lower) quartile groups, the good readers (n = 22) showed a significant locality effect for *sika* (t = 3.64, p < .001), and the poor readers (n = 20) showed no such effect (t = -0.25, p = .801). Figure 4 summarizes the contrast between good and poor readers regarding the mean RTs at the critical region.

Table 3: Results of linear mixed effects model analysis for Experiment 2.

	Estimate	SE	*t*-value	Pr(>|t|)
(Intercept)	705.2	24.3	29.07	.000 ***
Locality	3.6	7.7	0.47	.637
sika	18.7	13.2	1.41	.158
Only	39.8	13.2	3.00	.003 **
OnlyAff	−101.2	13.3	−7.63	.000 ***
CA	93.2	22.2	4.19	.000 ***
spillover	62.8	9.4	6.70	.000 ***
Locality:*sika*	17.9	13.2	1.36	.175
Locality:Only	−13.6	13.3	−1.02	.307
Locality:OnlyAff	−10.5	13.3	−0.79	.431
Locality:CA	13.6	7.7	1.76	.078
sika:CA	−0.8	13.4	−0.06	.954
Only:CA	9.8	13.4	0.73	.465
OnlyAff:CA	−37.5	13.4	−2.79	.005 **
Locality:*sika*:CA	34.9	13.4	2.60	.009 **
Locality:Only:CA	−9.5	13.4	−0.72	.475
Locality:OnlyAff:CA	−15.4	13.4	−1.15	.251

Signif. codes: 0 “***” .001 “**” .01 “*” .05 “.” 0.1 “ ” 1

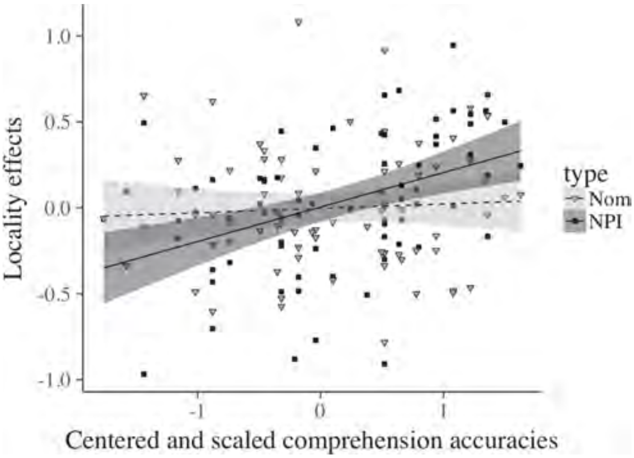

Figure 3: Differences between the log-transformed response times of the Distant conditions and those of the Local conditions at the critical verb region, as a function of centered and scaled comprehension accuracies.

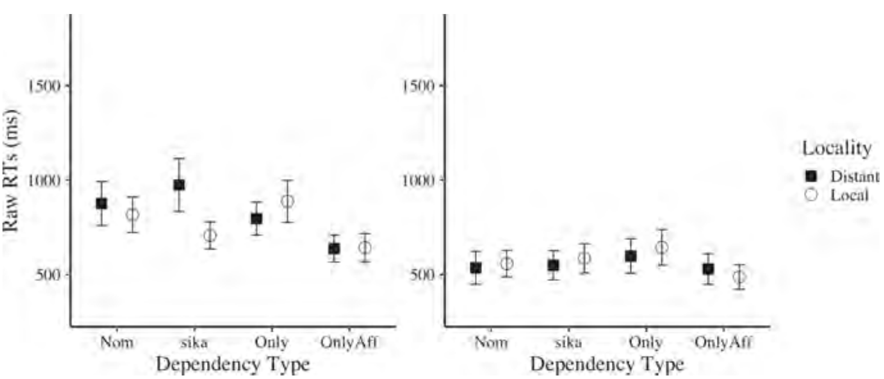

Figure 4: The mean raw response times of the critical region for the good readers (left) and the poor readers (right), with error bars representing 95% confidence intervals.

4.3 Discussion

Experiment 2 yielded similar results to Experiment 1, except for a weak indication of locality effects for *sika*. However, as in Experiment 1, there was a significant interaction between locality effects in the *sika* conditions and CA rates in such a direction that locality effects tended to be stronger when CA rates were higher. It suggests the possibility that the processing of NP-*sika* may be a function of reading comprehension skills because NPI-marker *sika* introduces an extra dependency that adds to memory load. The finding that the semantically comparable conditions with *dake* (Only / OnlyAff) did not match the *sika* conditions suggests that the obligatory setup of a new grammatical relation, not the semantic exclusivity per se, invoked a decay-based locality effect.

Although Experiments 1 and 2 yielded similar results, there was one clear contrast: the critical verb region was read faster in Experiment 2 than in Experiment 1 (703 ms vs. 909 ms), a strong indication of position effects (Ferreira and Henderson 1993). Recall that the target items in Experiments 1 and 2 were identical, except that the latter had one extra element (locative PP), which pushed the critical region one region away in the latter. The filler items were identical. We conducted a between-participants meta-analysis of the results of Experiments 1 and 2 combined (128 participants), using a model including the Experiment factor as a fixed effect to all the relevant factors. Table 4 summarizes the results, revealing a significant facilitation effect of the Experiment factor ($t = -5.36$, $p < .001$). Thus, as per several studies, varying the dependency distance by simply adding an intervening word is not appropriate for testing memory-based locality effects. The results confirmed a robust CA × Locality × *sika* interaction ($t = 3.41$, $p = .001$); no such interaction was found with other Dependency Types.

Table 4: Results of the meta-analysis of the combined results of Experiments 1 and 2 using a linear mixed effects model.

	Estimate	SE	*t*-value	Pr(>|t|)
(Intercept)	807.5	23.0	35.14	.000 ***
Experiment	−101.9	19.0	−5.36	.000 ***
Locality	7.5	7.2	1.04	.298
sika	41.0	12.5	3.28	.001 **
Only	58.1	12.5	4.64	.000 ***
OnlyAff	−141.7	12.5	11.32	.000 ***
CA	121.5	18.8	6.46	.000 ***
spillover	46.4	8.2	5.65	.000 ***
Locality:*sika*	16.4	12.5	1.31	.190
Locality:Only	−14.4	12.5	−1.15	.252
Locality:OnlyAff	−0.8	12.5	−0.06	.950
Locality:CA	21.0	7.3	2.88	.004 **
sika:CA	20.1	12.7	1.59	.112
Only:CA	24.6	12.6	1.95	.051 .
OnlyAff:CA	−52.3	12.7	−4.13	.000 ***
Locality:*sika*:CA	43.1	12.6	3.41	.001 ***
Locality:Only:CA	−20.6	12.6	−1.63	.102
Locality:OnlyAff:CA	−12.6	12.7	−1.00	.320

Signif. codes: 0 “***” .001 “**” .01 “*” .05 “.” 0.1 “ ” 1

5 General discussion

This study tested the hypothesis that locality effects are a function of dependency length and type. Adopting activation-based working memory retrieval models (Thibadeau, Just, and Carpenter 1982; King and Just 1991; Vasishth and Lewis 2006), we assumed that non-thematic dependencies are more prone to memory decay when dependency lengths are greater because they tend to be linearly discontinuous and, thus, do not receive maintenance support from intervening elements in working memory. We conducted two self-paced reading experiments to test whether NPI-marker *sika* would invoke a locality effect relative to its nominative control. In Experiment 1, there was no interaction of *sika* and Locality; in Experiment 2, the dependency length in the distance conditions was greater by one word, though we only found a marginal tendency toward an interaction. However, when we included participants' CA rates in the models, both experiments yielded a significant three-way interaction of *sika*, Locality, and participants' CA rates, such that better readers tended to show greater locality effects (i.e., longer reading times when *sika* was distant). Such an interaction was not found with semantically comparable *dake* "only," suggesting that the requirement for polarity triggered by *sika* incurred an extra complexity that selectively affected good readers. However, why was the locality effect with *sika* a function of comprehension performance?

Prior findings suggest interactions between working memory capacities and reading behaviors. It is known that individual differences in working memory capacity induce differences in reading times and CAs, interacting with structural factors (Just and Carpenter 1992; King and Just 1991; MacDonald, Just, and Carpenter 1992). Nicenboim et al. (2016) find an interaction between locality effects and individual working memory capacities such that locality effects were greater with high-capacity readers, while an anti-locality trend was found with readers with lower working capacity. They conjecture that this interaction is an indication of forgetting effects (Gibson and Thomas 1999): low-capacity readers tended to lose track of longer dependencies, failing to integrate them, thus failing to show locality effects. MacDonald, Just, and Carpenter (1992) probe the processing complexity of ambiguous sentences and report that high-span readers showed longer reading times than low-span readers. They also find an interaction of the capacity factor and the ambiguity factor such that the slowdown effects of temporal ambiguity were greater with high-span readers. They conclude that high-span readers could maintain multiple structural analyses for a longer period than low-span readers.[4]

4 King and Just (1991) probe the interaction between working memory capacity and the processing complexity of relative clauses (subject- vs. object-extraction) and report seemingly opposite

Many previous studies report that the working memory measure is highly correlated with general reading skill measures, including CAs.

Thus, we conjecture that poor readers likely to have lower working memory capacity are more likely to lose track of multiple dependencies (cf. MacDonald et al. 1992). Note the hypothesis that the presence of NPI-marker *sika* would introduce an extra dependency. Assumedly, the distance-based retrieval cost for *sika* was found only with good readers because they could successfully keep multiple dependencies in working memory. These findings are highly compatible with Nicenboim et al. (2016), where low working memory capacity readers tended to show anti-locality effects, while high-capacity readers tended to show locality effects. The results are also compatible with MacDonald et al. (1992), where high-capacity readers could track multiple analyses of locally ambiguous sentences and, thus, were slower than low-capacity readers. Although comprehension question accuracy cannot be considered directly reflective of working memory capacity, working memory capacity is highly correlated with various reading skills (Just and Carpenter 1992; King and Just 1991; MacDonald et al. 1992). It is measured by complex tasks (see Conway et al. 2005 for review) and, thus, is regarded as an attention-inhibition component and a storage component (Conway and Engle 1994; Engle et al. 1999). Keeping track of multiple distinct dependencies may be comparable to complex memory tasks. We assume individual working memory capacities and individual comprehension performances affect reading behaviors in the same direction, but the validity of this claim needs further examination, which is left open for future research.

One final issue that should be addressed is the question of what type of expectation for a dependency would incur a decay-driven retrieval cost. For example, Husain, Vasishth, and Srinivasan (2014) tested the interaction of locality effects and the strength of expectation in Hindi. They employed idiomatic noun-verb combinations, such as *khayaal rakhnaa* "(lit.) care keep" = "take care of," against non-idiomatic combinations, such as *gitaar rakhnaa* "guitar keep," to vary the expectation factor. They found anti-locality effects when the noun triggered a strong expectation for a specific verb (*khayaal . . . rakhe*) but not when it did not (*gitaar . . . rakhe*). Thus, the strong expectation for a specific verb worked in the opposite direction to the grammatical expectation for a Neg triggered by an NPI in our experiments. It indicates that the expectation based on a fixed complex expression is qualitatively different from the expectation for Neg triggered by an NPI. In the former

results to those of Nicemboim et al. (2016) and MacDonald et al. (1992), such that low-span readers showed greater reading times with object-extracted relative clauses, assumed to be structurally more complex than subject-extracted ones. Interestingly, King and Just (1991) also reported that this effect was absent with "non-readers" whose CA rates were at chance levels.

case, the expectation is thematic: when *khayaal* "care" is encountered, the thematic interpretation "take care of" is immediately established; in this sense, this "expectation" is part of the already present thematic chain. However, the computation of the NPI-Neg dependency hinges upon the completion of the thematic computation of the proposition. It may explain why the latter type of dependency, not the former, poses some working memory load and may incur locality effects.

One may conclude that the qualitative difference between the expectation based on idiomatic noun-verb complex expressions on the one hand and that based on NPI-Neg dependencies as well as *wh*-gap dependencies on the other hinges on the presence (absence) of a syntactic feature (i.e., the latter dependencies incur locality effects because they involve formal syntactic checking operations). However, Nakatani (2021) reports locality effects of maximally positive adverbials marked with contrastive marker *wa* (e.g., *hakkirito-wa* "clearly"), which behave like a negative polarity item. It is not very plausible to assume that these adverbial "pseudo-NPIs" involve a formal syntactic NPI feature that must be checked because it is not completely ungrammatical for them to appear in an affirmative context without Neg (see Nakatani 2021 for details). Therefore, the type of dependency that counts as an extra dependency is not exclusively limited to formal syntactic feature-checking relations. Further research is needed to explicate what type of expectation for a head to come leads to the establishment of "multiple" dependencies that may incur locality effects.

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Chapter 4
An EEG analysis of long-distance scrambling in Japanese: Head direction, reanalysis, and working memory constraints

1 Introduction: Constraints on discontinuous dependency

In a natural language sentence, two morphemes discontinuous in a time series can establish a semantically closer relationship than their adjacent morphemes. The words underlined in (1) are some examples.

(1) a. <u>If</u> you don't feel well, <u>then</u> you can go home right away.
 b. I do<u>n't</u> want <u>any</u>body to disturb me.
 c. A <u>review</u> came out yesterday <u>of this book</u>.
 d. The <u>woman</u> who you were talking <u>about</u> is my sister.

Discontinuous dependency is cross-linguistic. In the Japanese examples in (2), the underlined words establish discontinuous dependency (the abbreviations *-NOM*, *-TOP*, and *-ACC* mean nominal, topic, and accusative, respectively).

(2) a. If. . ., then

Moshi	*netsu-ga*	*aru-nara,*	*kaette*	*yasumi-nasai.*
If	fever-NOM	exist then	go home	to rest

"If you have a fever, then you should go home to rest."

b. Negative polarity item

Sofu-wa	*joobu-de*	*ichido-<u>shika</u>*	*kaze-o*
grandfather-TOP	strong	once only	cold-ACC

hiita-koto-ga <u>nai</u>.
had fact-NOM not
"My grandfather is so strong that he has had a cold only once."

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c. Quantifier floating
Chichi-wa *san-bai* *asagohan-ni* *coffee-o* *nomimashita.*
father-TOP three breakfast at coffee-ACC drank
"My father drank three cups of coffee at breakfast."

Discontinuous dependency is evidence that the set of sentences of a natural language exceeds the generative capacity of finite-state grammar. This phenomenon is, thus, critical for the study of the computational nature of natural language, and researchers on syntax and sentence processing have intensively discussed the dependency.

Discontinuous dependency can cross the clause boundaries of verbal complement declaratives. In (3), for example, *what* can be interpreted as the object of *bought*, and the number of the embeddings is unlimited in principle (*S* represents "sentence").

(3) a. What do you know that [$_S$ John bought yesterday]?
b. What do you know that [$_S$ Bill thinks that [$_S$ John bought yesterday]]?
c. What do you know that [$_S$ George believes that [$_S$ Bill thinks that [$_S$ John bought yesterday]]]?

However, it is well known that discontinuous dependency cannot always cross clause boundaries. In (4), for example, *what* cannot be interpreted as the object of *bought*. The examples in (4) indicate that discontinuous dependency is affected by syntactic environments. A complex noun phrase (NP) in (4a,b) and an adverbial adjunct clause in (4c) interfere with the dependencies (*PP* is the abbreviation for "prepositional phrase").

(4) a. *What do you know [$_{NP}$ the rumor that [$_S$ John bought yesterday]]?
b. *What do you know [$_{NP}$ the dealer where [$_S$ John bought yesterday]]?
c. *What was Bill reading a magazine [$_{PP}$ when [$_S$ John bought yesterday]]?

The constituent that blocks discontinuous dependency is called the *syntactic island* in linguistic studies. A complex NP and an adverbial adjunct clause are examples of syntactic islands in English.

The word order in a Japanese sentence is relatively free; therefore, we can discuss the discontinuous dependencies in Japanese corresponding to those in the English examples by preposing subordinate objects by scrambling. The preposed *sono hon-o* (that book-ACC) in (5) can be interpreted as the object of *katta* (bought). The dependency crosses the clause boundary of a verbal complement declarative in the same manner as in (3).

(5) Japanese discontinuous dependency crossing the boundary of a verbal complement declarative.

<u>Sono hon-o</u>	*Hanako-ga*	*[$_S$ Taroo-ga katta]-to*	*omotteiru.*
that book-ACC	name-NOM	name-NOM bought-COMP	think

"That book, Hanako thinks that Taroo bought." (Saito 1992)

The island phenomenon is assumed to be cross-linguistic, though syntactic categories that constitute islands can vary among languages (Goodluck and Rochemont 1992). Note that the effect of possible islands in Japanese sentences is mild, whereas the island effect in English is salient. Kuno (1973), for example, considers (6) to be marginal, with the subordinate object preposed from the inside of a complex NP.

(6) Japanese discontinuous dependency crossing the boundary of the nominal complement declarative in a complex NP.

<u>?Saburoo-o</u>	*Taroo-wa*	[$_{NP}$ [$_S$ *Hanako-ga*	*<u>nikundeiru</u>*]-*toiu*
name-ACC	name-TOP	name-NOM	hate-COMP
uwasa]-*o*	*shinziteita.*		
rumor-ACC	believed		

"As for Saburoo$_i$, Taro believed the rumor that Hanako hated him$_i$."

Furthermore, sentences in (7) are considered grammatical, with one of the discontinuous elements in a complex NP in (7a) and in an adverbial adjunct clause in (7b).

(7) a. Japanese discontinuous dependency crossing the boundary of the nominal complement declarative in a complex NP.

<u>Sono hon-o</u>	*Jon-ga*	[$_{NP}$ [$_S$ *Mary-ga*	*<u>katta</u>*]-toiu
that book-ACC	John-NOM	Mary-NOM	bought-COMP
uwasa]-o	kiita.		
rumor-ACC	heard		

"(As for) that book, John heard the rumor that Mary had bought (it)."

(Nakamura 2001)

b. Japanese discontinuous dependency crossing the boundary of an adverbial adjunct clause.

Bungakubu-ni	*Taro-wa*	[$_{PP}$ [$_S$ *Jiroo-ga*
faculty of letters-DAT	name-TOP	name-NOM
nyuugakushita]-*node*]	*odoroita.*	
entered-because	got surprised	

"(As for) a faculty of letters, Taro got surprised because Jiroo had entered (it)."

(Mihara 2000)

Sprouse, Wagers, and Phillips (2012) presented English sentences to native speakers of English and asked them to evaluate their acceptability by choosing one of the seven scales. In generating experimental sentences, they manipulated two factors (i.e., the presence or absence of discontinuous dependency and that of a construction that could function as a syntactic island), keeping the propositional meaning of a subordinate clause unchanged as much as possible. Sprouse, Wagers, and Phillips (2012) succeeded with this manipulation in dividing the island effect into the effect of the discontinuous dependency and that of the presence of island construction. The island effect was statistically evaluated as the interaction of the two factors, and the acceptability of an island construction was relatively evaluated by the reference to the acceptability of other constructions. Tokimoto (2019) followed the method of Sprouse, Wagers, and Phillips (2012) to compare the (possible) island effect in Japanese with the island effects in English. Accordingly, (8a) is one of the stimulus sentences in Sprouse, Wagers, & Phillips (2012), and (8b) is its counterpart in Tokimoto (2019).

(8) a. What did the chef hear the statement that [Jeff baked]?

b.

何を,	料理長は,	［奥田さんが	焼いた］	話を
what-ACC	chef-TOP	Mr/Ms. Okuda-NOM	baked	statement-ACC
聞いたんですか?				
heard-interrogative				

Tokimoto (2019), unlike Sprouse, Wagers, and Phillips (2012), observed no significant interaction between the two factors for possible island constructions in Japanese (i.e., adverbial adjunct clauses, complex noun phrases, and indirect questions).

Note a typological difference in the processing time course of (possible) island constructions between English and Japanese, schematically shown in Figure 1 for the examples in (8). In Figure 1A, for a complex NP in English, the presence of a biclausal dependency is recognized at the head noun *statement*, and the syntactic relationship between *what* and its counterpart to come (*baked*) is also recognized here. For a complex NP in Japanese in Figure 1B, however, the processing time course can be divided into two steps. That is, the presence of a biclausal dependency is recognized at the subordinate subject 奥田さんが (Mr/Ms. Okuda-NOM) because no Japanese verb takes three consecutive NPs case-marked as *-o* (-ACC), *-wa* (-TOP), and *-ga* (-NOM) as its arguments. The syntactic relationship between 何を (what-ACC) and the subordinate verb 焼いた (baked) is recognized at the head noun 話 (statement) of the complex NP. Hence, the effects of establishing discontinuous dependency and syntactic computation between the discontinuous elements can be confounded in English. In Japanese sentences, we can experimentally examine these two processes independently given the head-final nature.

This chapter examines the possibility that the difference in the time course of sentence processing between English and Japanese can affect the degree of island effects. The basic assumption is stated in (9).

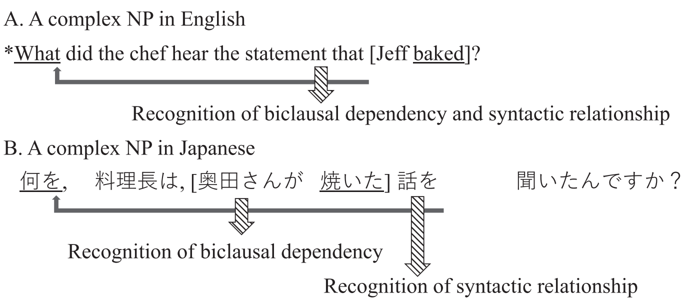

Figure 1: Typological difference in the processing time course of biclausal discontinuous dependency between English and Japanese.

(9) Basic assumption for linguistic judgments
A linguistic judgment is a result of language processing in real-time (like a visual illusion). The time course of a sentence processing can, thus, affect grammatical judgment.

We discuss the electroencephalogram (EEG) associated with the processing of possible syntactic islands in Japanese to examine its time course in detail.

McKinnon and Osterhout (1996) examine the event-related potential (ERP) linked with the violation of syntactic island constraints in English. They visually presented (10) word by word and observed a late positivity (P600) for *when* in (10b) against (10a) in the centro-parietal and occipital regions.

(10) a. I wonder whether the candidate was annoyed [when his son was questioned by his staff member]
b. *I wonder which of his staff members$_i$ the candidate was annoyed [when his son was questioned by e_i].

However, some researchers attribute island constraints to the constraints of working memory (Kluender 1998). From this theoretical standpoint, a sentence is assumed to be ungrammatical when the processing load of linguistic forms between discontinuous elements exceeds a threshold, and, thus, the access to the antecedent of the filler at a gap becomes challenging, with the assumption that processing and retention of information share a single resource (Just and Carpenter 1992). Accordingly, Kluender and Kutas (1993) visually presented sentences of (11) word by word and observed left anterior negativity (LAN) for *the* in (11c) relative to (11a). The indirect question in (11c) is one of the syntactic islands in English, and the anterior negativity is claimed to be a manifestation of an additional working memory load.

(11) a. Verbal complement declarative
Who$_i$ has she forgotten [that THE boss referred that matter to e_i for further study]?
b. Verbal complement *if*-clause
Who has she forgotten [if THE boss referred that matter to e_i for further study]?
c. Indirect question
*Who$_i$ has she forgotten [what$_j$ THE boss referred e_j to e_i for further study]?

The processing point of the recognition of discontinuous dependency and that of the syntactic computation of the discontinuous elements are different in Japanese, as in Figure 1B. Therefore, apparently contradicting findings in English can be reevaluated by the reference to the findings in Japanese. The research questions are enumerated in (12).

(12) a. Can we find different neural activities corresponding to the different head directions in English and Japanese?
b. Can we find a correspondence between expected ERPs and the processing contents?
c. Can we attribute the relative weakness of the island effect in Japanese to its typological properties in sentence processing?

In the following sections, we discuss our experiment to record the EEG elicited by Japanese sentences with the long-distance scrambling of the subordinate object from a verbal complement or an adverbial adjunct clause.

2 Experiment

2.1 Method

2.1.1 Participants

Twenty-two native speakers of Japanese between 20 and 42 years old (*M* = 23.5 years *SD* = 5.49 years, 15 females) participated in this study for payment. The participants had normal or corrected-to-normal vision and had no history of neurological or psychiatric disorders. All the participants were right-handed, as per a handedness questionnaire (Oldfield 1971). This study was approved by the ethics committee of Mejiro University. Written informed consent was obtained from each participant.

2.1.2 Materials

We generated experimental sentences of six phrases with three within factors manipulated, as in (13).

(13) a. Type of subordinate clause: Verbal complement declarative (Comp) or adverbial adjunct clause (Adjunct)
b. Word order: Canonical or scrambled
c. Subordinate subject: Proper name or the first-person singular pronoun

The syntactic status of a subordinate clause was manipulated by changing the particle at the end of a subordinate clause to *-to* (that) for a verbal complement declarative or *node* (because) for an adverbial adjunct clause. Adverbial adjunct clauses were intended to be a possible syntactic island in Japanese relative to a non-island verbal complement declarative. Discontinuous dependency was implemented by a long-distance scrambling of a subordinate object to the sentence-initial position. We manipulated the processing load on working memory by changing the subordinate subject to be a proper name or the first-person singular pronoun *watashi* with the assumption that a proper noun is more costly than the first-person pronoun. The relatively light processing load of a pronoun can be observed in a sentence with center embeddings. A doubly center-embedding is widely known to cause processing difficulty, but some researchers have recognized that center-embedded sentences are relatively easy to process when the most embedded NP is a first- or second-person pronoun, as in (14b-d) against (14a). According to Warren and Gibson (2002), integrating a new word across linguistic material indicating a new discourse referent is more costly than integrating a word across linguistic material, referring back to a pre-existing discourse referent. In (14a), for example, two discontinuous subject-verb relationships are included—*nanny . . . was adored* and *the agency . . . sent*—and the subjects must be retrieved at the input of their corresponding verbs with the most deeply embedded subject—*the neighbors*—intervening between the two discontinuous dependencies as a new discourse referent. However, in (14b-d), the most deeply embedded subjects *I* in (14b,d) and *you* in (14c) intervene between the subsect-verb relationships, but a first- or a second-person pronoun does not build a new discourse referent because the referents of *I* and *you* are assumed to be a default part of the domain of discourse, even in a null context, given that every discourse has a speaker-writer and a listener-reader (Kamp and Reyle 1993). Thus, (14b-d) are easier to process than (14a) because greater mental resources are available for the former than the latter to retrieve the subjects at the verbs.

(14) a. The nanny who the agency which the neighbors recommended sent was adored by all the children. (Warren and Gibson 2002)
b. The reporter who everyone that I met trusts said the president won't resign
yet. (Bever 1974)
c. Isn't it true that example sentences that people that you know produce are more likely to be accepted? (De Roeck et al. 1982)
d. A book that some Italian I've never heard of wrote will be published soon by MIT Press. (Frank 1992)

In our experimental scrambled sentences, the matrix subjects intervene between the preposed subordinate objects and their corresponding subordinate verbs. Therefore, we can expect that a proper name will be more demanding for working memory than the first-person pronoun in processing the discontinuous object-verb relationships.

Table 1 shows some of the experimental sentences. One hundred and 60 sentences were generated for each of the two types of sentences with the subordinate subjects as proper names for the first half and as the first-person singular pronoun for the second half. The experimental sentences with scrambled order were generated from the sentences with canonical order by long-distance scrambling. In generating the experimental sentences, repetition of words was avoided, except for proper names, which were unaccented and comprised two characters and three morae. The number of characters of morae and the initial sequence of accents in a sentence were controlled for the two types of sentences. Eighty fillers were included in the main session. The 320 experimental sentences and 80 fillers were randomly divided into four blocks.

2.1.3 Procedure

The participants were seated in an electrically and acoustically shielded EEG chamber 1 m in front of a 19-inch LCD monitor. Each trial began with a button press by a participant, and a fixation point followed the button press at the center of the monitor for 1 second. A stimulus sentence was visually presented, phrase by phrase, after the fixation at the center of the monitor with a stimulus onset asynchrony of

Table 1: Selected experimental sentences (discontinuous elements indicated by underlines).

(1) Verbal complement declarative					
P1	**P2**	**P3**	**P4**	**P5**	**P6**
a. Canonical order					
村田は	[安達/私が	筆箱を	盗んだ]と	クラスメートに	言い張った。
name-TOP	name/'I'-NOM	pencil case-ACC	stole-COMP	classmates-DAT	insisted
b. Scrambled order					
筆箱を	村田は	[安達/私が	盗んだ]と	クラスメートに	言い張った。
'Murata told the classmates that Adachi/I had stolen the pencil case.'					
(2) Adverbial adjunct clause					
P1	**P2**	**P3**	**P4**	**P5**	**P6**
a. Canonical order					
奥田は	[太田/私が	パソコンを	壊した]ので	電気店に	電話した。
name-TOP	name/'I'-NOM	PC-ACC	broke-because	electronics store-DAT	phoned
b. Scrambled order					
パソコンを	奥田は	[太田/私が	壊した]ので	電気店に	電話した。
'Okuda phoned the electronics store because Ohta/I had broken the PC.'					

800 ms and an interstimulus interval of 100 ms. The participants were required to judge grammaticality by pushing a button for each sentence ("grammatical" or "ungrammatical"). The order of the presentation of the stimulus sentences was pseudorandomized for each participant. The experiment was controlled using STIM2 software (Neuroscan). The practice session comprised 10 trials, the main session comprised four blocks, and the participants were allowed to rest for three to five minutes between blocks. The experimental sessions, including instruction and electrode applications, lasted approximately two hours.

2.1.4 Electroencephalogram recording

A continuous EEG was recorded from 21 Ag/AgCl sintered electrodes mounted on an elastic cap (19 positions of the international 10/20 system, and FCz and Oz). Vertical and horizontal electrooculograms (EOG) were simultaneously recorded from electrodes below the left eye (VEOG) and at the outer canthus of the right eye (HEOG). The signals were sampled at 500 Hz with a bandpass filter of DC to 100 Hz with the reference electrodes positioned at the two earlobes. The electrode impedance was maintained at a level lower than 10 kΩ during the sessions. The EEG data were continuously acquired using SCAN4 software (Neuroscan).

2.1.5 Electroencephalogram data preprocessing

The acquired EEG data were processed offline using EEGLAB (Delorme and Makeig 2004). The preprocessing steps were as follows. (1) The data were high-pass filtered at 1 Hz to minimize low drifts with the reference of linked earlobes. (2) Line noise was removed using the CleanLine plugin in EEGLAB. (3) High-amplitude artifacts were removed from the EEG data using artifact subspace reconstruction (Mullen et al. 2015). (4) The data were decomposed using an adaptive mixture of independent component (IC) analyzers (AMICA) (Palmer et al. 2007). (5) We calculated the best-fitting single-equivalent current dipole for each IC to match the scalp projection of each IC source using a standardized three-shell boundary element head model. We aligned the electrode locations according to the 10–20 system with a standard brain model (Montreal Neurological Institute). (6) We evaluated the possibilities of the sources for each IC with the ICLabel plugin in EEGLAB (Pion-Tonachini, Makeig, & Kreutz-Delgado 2017): brain neural activity, EOG, muscle potentials, electrocardiogram, line noise, channel noise, and other. We chose the ICs for which the possibility of brain neural activity was greater than 70% for the following analyses. (7) We excluded ICs from further analysis for instances in which the equivalent dipole model explained less than 85% of the variance in the corresponding IC scalp map. (8) We segmented the data into time epochs from −1 to 2 seconds relative to the event markers.

2.2 Results

2.2.1 Behavioral results: Grammatical judgments

Figure 2A presents the mean grammatical judgment rates for the two types of subordinate clauses, two word orders, and two subordinate subjects. Figure 2B presents their decision tree as independent variables. The main word order effect was significant, and grammatical judgments were significantly more for Comp than Adjunct in canonical and scrambled orders. The subordinate subjects exhibited no significant effect.

2.2.2 Event-related potential analysis

We analyzed the ERP at the third and the fourth phrases with a prestimulus baseline of 100 ms. The comparison between the conditions was corrected by cluster-based permutation tests. The analyses of the condition effects in ERP were performed using the STUDY command structure in EEGLAB. Nonparametric random permutation sta-

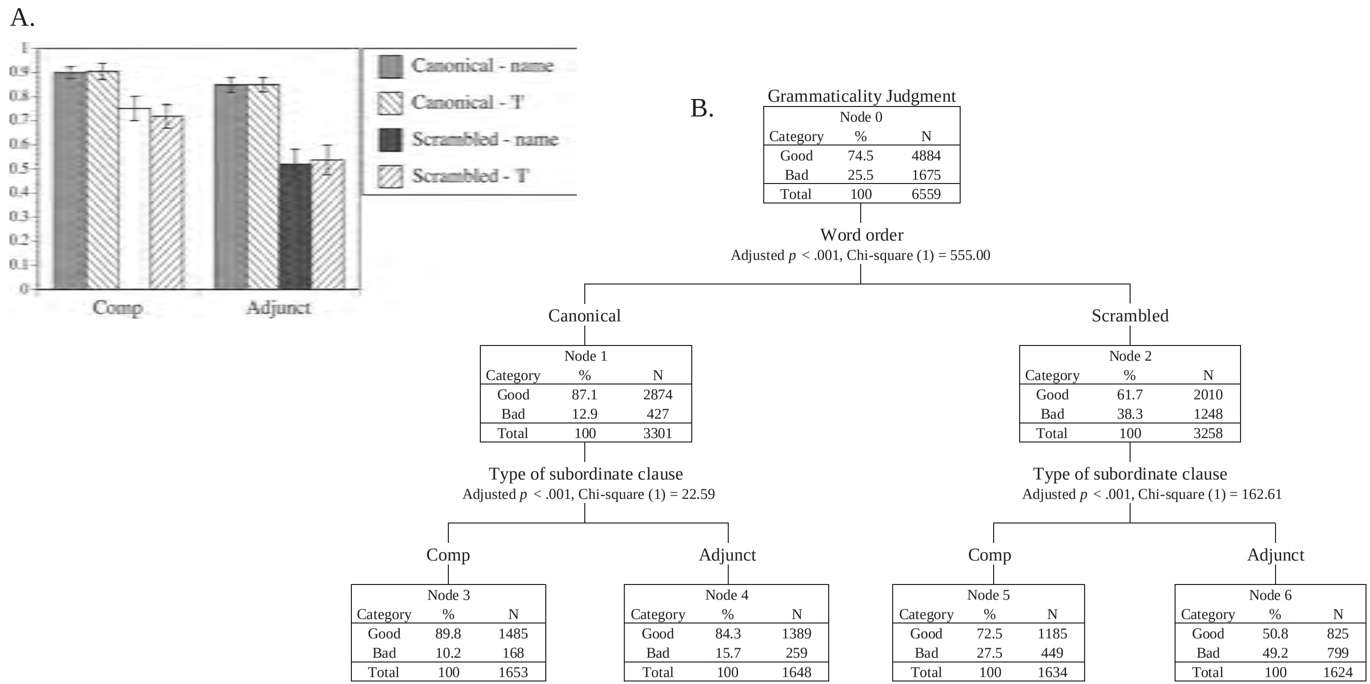

Figure 2: (A) Mean grammatical judgment rates for two types of subordinate clauses, two word orders, and two subordinate subjects. The error bars indicate the standard errors. (B) The decision tree for the grammatical judgments with the two types of subordinate clauses, two word orders, and two subordinate subjects as independent variables.

tistics were computed to test the significance of the condition effects. In this study, we computed 2,000 random permutations and compared them to the *t*-values for the mean condition differences.

Event-related potential at the third phrase

The processing contrast in the third phrases between canonical and scrambled orders is shown in (15). No Japanese verb takes a topically marked human NP, a nominatively marked human NP, and an accusatively marked NP as its arguments. Therefore, the presence of a complex sentence is recognized here.

(15) a. Canonical order
P1 P2 P3
NP-TOP [name/'I'-NOM NP-ACC . . .
b. Scrambled order
P1 P2 P3
NP-ACC NP-TOP [name/'I'-NOM . . .

Further, in scrambled order, the sentence-initial accusatively marked NP can establish a discontinuous dependency with the verb to come later given that the topic NP in the second phrase intervenes between the two.

Figure 3 presents ERPs time-locked to the onsets of the third phrases for canonical and scrambled orders. We observed a significant anterior negativity, but the negativity did not reach a significant level in the topography of the standard LAN/N400 (300 to 500 ms) time window. We also observed a significant parietal-occipital positivity for the P600 (500 to 800 ms) standard time window. No significant difference was observed at the two EOG electrodes (VEOG and HEOG) in the –100–800 ms time window.

Figure 4 presents ERPs time-locked to the onsets of the third phrases for the two different subordinate subjects for canonical and scrambled orders. The anterior negativity reached a significant level in the topography of 300 to 450 ms only when the subordinate subjects were proper names. The ERP waveforms at frontal electrodes indicated that the anterior negativity lasted longer for the proper names than for the pronoun. Table 2 presents the correlation between the maximum amplitude of the anterior negativity and the parietal-occipital positivity in the time windows in which the contrasts between the canonical and scrambled orders were significant in the topography (250 [500] to 350 [800] ms for the negativity [positivity]). The correlations between the negative ERP and the positive ERP were almost significant (r = 0.42, p = .053). The mean amplitudes of the negativity were negative; thus, the positive correlation coefficient indicates that a participant with a greater negative ERP magnitude showed a smaller positive ERP magnitude.

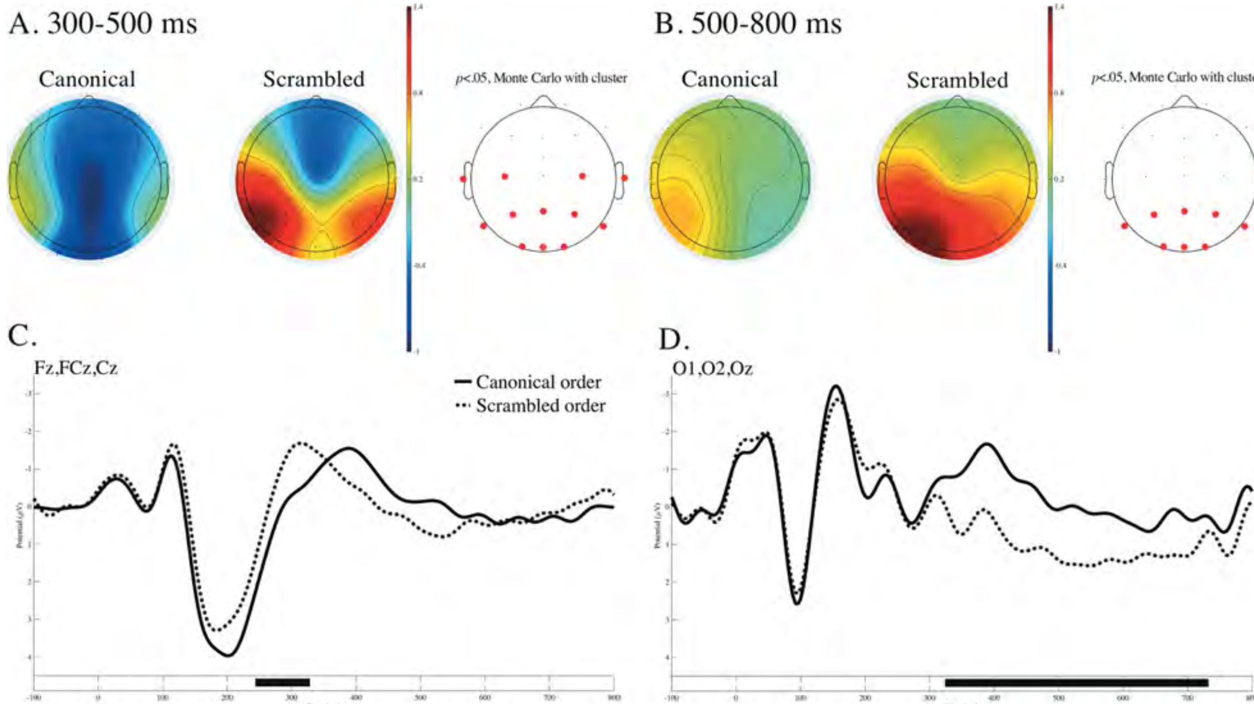

Figure 3: ERPs time-locked to the onsets of the third phrases for canonical and scrambled orders (A–D) with the prestimulus baseline from–100 to 0 ms. (A) Mean topographies of the ERPs from 300 to 500 ms, and (B) those from 500 to 800 ms. The electrode sites at which significant differences were found using the cluster-based permutation test ($p < .05$) are depicted in red. (C) Mean ERP waveforms of the two conditions at the frontal-central electrodes (Fz, FCz, and Cz), and (D) those at the occipital electrodes (O1, Oz, and O2) from –100 to 800 ms. Negativity is plotted upward, and the approximate temporal extensions of the significant clusters are indicated in black on the time axis in (C, D).

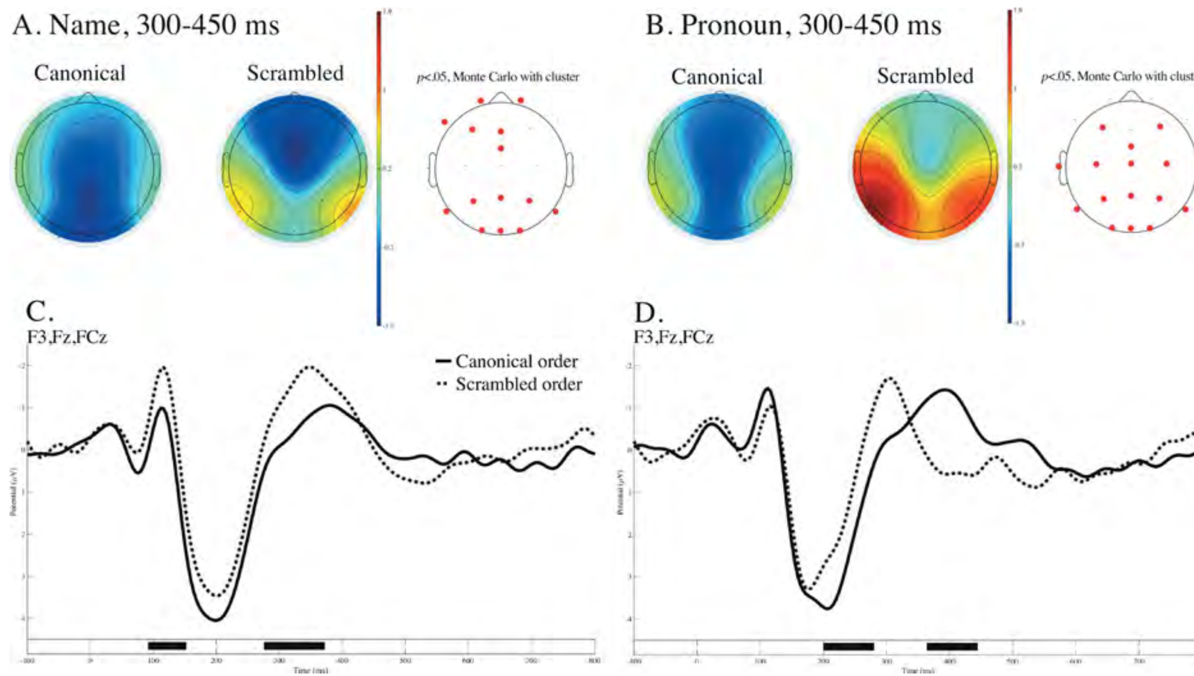

Figure 4: Event-related potentials time-locked to the onsets of the third phrases for the two subordinate subjects for canonical and scrambled orders (A–D) with the prestimulus baseline from −100 to 0 ms. (A) Mean topographies of the ERPs from 300 to 450 ms with proper names as the subordinate subjects, (B) those with the first-person singular pronoun as the subjects. The electrode sites at which significant differences were found using the cluster-based permutation test ($p < .05$) are depicted in red. (C) Mean ERP waveforms of the two conditions at the left frontal electrodes (F3, Fz, and FCz) for the proper names, and (D) those for the pronoun from −100 to 800 ms. Negativity is plotted upward, and the approximate temporal extensions of the significant clusters are indicated in black on the time axis in (C, D).

Table 2: Means of the maximum amplitudes of the anterior negativity and the parieto-occipital positivity (SD), with *r* as their correlation coefficient.

	Negative ERP	**Positive ERP**	***r***
Electrodes	FP1, FP2, F7, F3, Fz, F4, F8, FCz, Cz	P7, P3, Pz, P4, P8, O1, Oz, O2	
Time window (ms)	250–350	500–800	
Mean of the maximum amplitudes (μV, SD)	−1.29 (1.17)	1.72 (0.89)	0.42⁺

⁺*p* < 0.1

Event-related potential at the fourth phrase

The processing contrast in the fourth phrases between Comp and Adjunct is schematically shown in (16) and (17), respectively (Discontinuous elements are indicated by underlines). The thematic correspondence between the sentence-initial NP and the subordinate verb and their syntactic relationship is established here.

(16) Verbal complement declarative

a. Canonical order

P1	P2	P3	P4
NP-TOP	[NP-NOM	NP-ACC	verb]-complementizer . . .

b. Scrambled order

P1	P2	P3	P4
NP-ACC	NP-TOP	[NP-NOM	verb]-complementizer . . .

(17) Adverbial adjunct clause

a. Canonical order

P1	P2	P3	P4
NP-TOP	[NP-NOM	NP-ACC	verb]-*because* . . .

b. Scrambled order

P1	P2	P3	P4
NP-ACC	NP-TOP	[NP-NOM	verb]-*because* . . .

Figures 5 and 6 respectively present ERPs time-locked to the onsets of the fourth phrases for the two types of subordinate clauses for canonical and scrambled orders. We observed a significant negative deflection for scrambled order relative to canonical order in the parietal-occipital region in the 400–500 ms time window for Comp and Adjunct. We also observed a positive deflection in the broad regions for scrambled relative to canonical order in Adjunct in the 600–800 ms time window. No significant difference was observed at the two EOG electrodes in the

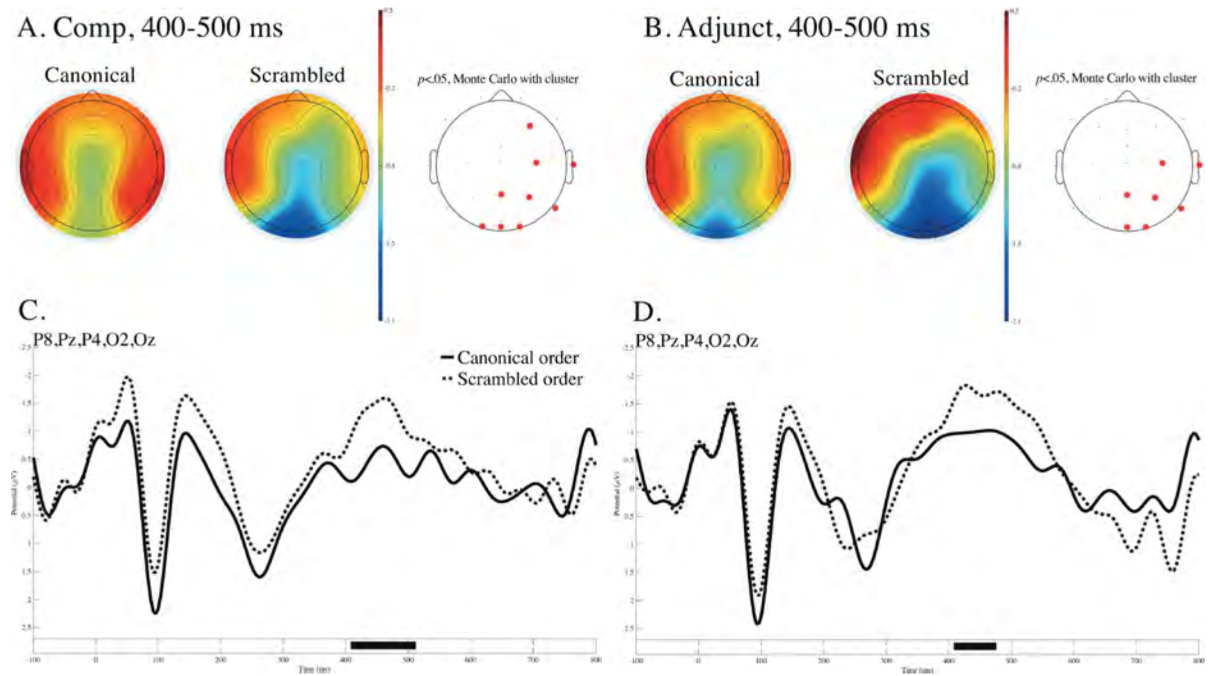

Figure 5: ERPs time-locked to the onsets of the fourth phrases for the two types of subordinate clauses for canonical and scrambled orders (A–D) with the prestimulus baseline from −100 to 0 ms. (A) Mean topographies of the ERPs from 400 to 500 ms for verbal complement declaratives (Comp), and (B) those for adverbial adjunct clauses (Adjunct). The electrode sites at which significant differences were found using the cluster-based permutation test ($p < .05$) are depicted in red. (C) Mean ERP waveforms of the two word orders at the parietal-occipital electrodes (P8, Pz, P4, O2, and Oz) from −100 to 800 ms for Comp, and (D) those for Adjunct. Negativity is plotted upward, and the approximate temporal extensions of the significant clusters are indicated in black on the time axis in (C, D).

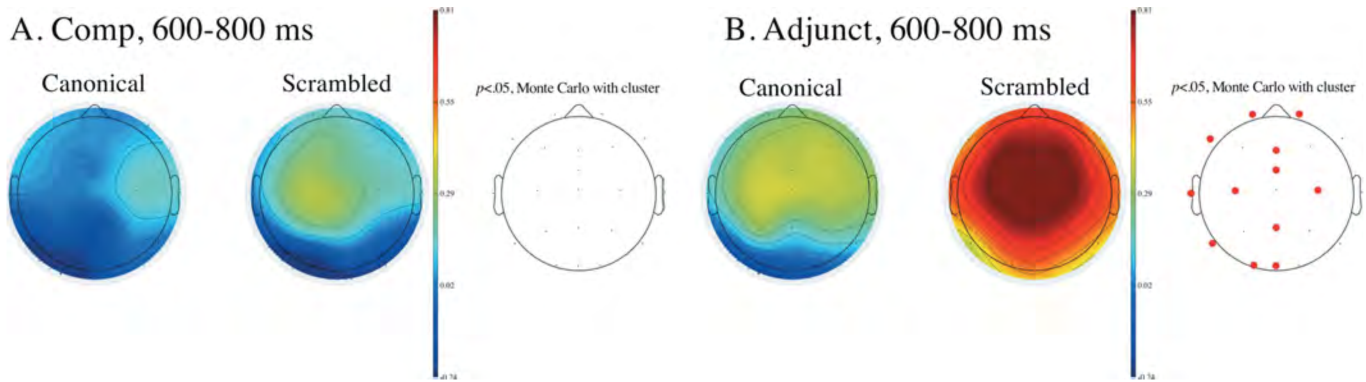

Figure 6: ERPs time-locked to the onsets of the fourth phrases for the two types of subordinate clauses for canonical and scrambled orders (A–B) with the prestimulus baseline from −100 to 0 ms. (A) Mean topographies of the ERPs from 600 to 800 ms for verbal complement declaratives (Comp), and (B) those for adverbial adjunct clauses (Adjunct). The electrode sites at which significant differences were found using the cluster-based permutation test ($p < .05$) are depicted in red.

–100–800 ms time window. The peak latency of the positivity at FP1 and Fz was positively correlated with the individual grammatical judgment rate for the scrambled Adjunct sentences.

3 Discussion

We observed anterior negativity in the third phrase in scrambled order, and the negativity was more salient when the subordinate subject in the third phrase was a proper name than when it was the first-person singular pronoun. We can, thus, understand the anterior negativity to be a manifestation of additional working memory load for the discontinuous dependency because a proper name introduces a new discourse referent whereas a first-person pronoun does not. A parietal-occipital positivity followed the anterior negativity, and the positivity at this processing point was often interpreted as a manifestation of syntactic integration at the "pregap position" between the sentence-initial subordinate object and the subordinate verb to come, with the assumption that a gap is placed at the base position of a subordinate object from which the object is moved to the beginning of the sentence (Hagiwara et al. 2007). Note that some researchers have claimed that biphasic negativity and positivity can be functionally linked (Van De Meerendonk et al. 2008; Kim, Oines, & Miyake 2018). In our experiment, the magnitude of the parietal-occipital positivity was negatively correlated with that of the preceding negativity, which suggests that the two ERPs are functionally linked. A late positivity (P600) can be elicited by a reanalysis. *The defendant* in (18a) is temporarily ambiguous between the matrix object and the subordinate subject, and it is preferably interpreted as the former. Thus, we can assume that *the defendant* is reanalyzed as the subordinate subject at the input of *was*. As one of the early relevant studies, Osterhout, Holcomb, and Swinney (1994) visually presented (18) word by word with the SOA and the ISI set to 650 and 300 ms, respectively, and they observed a positive ERP for *was* in (18a) relative to (18b) in the 500–800 ms time window in the parietal-occipital region.

(18) a. The lawyer charged the defendant was lying.
b. The lawyer charged that the defendant was lying.

In our scrambled sentences, the sentence-initial accusatively marked NP is processed as an element of a simple sentence by default; thus, it is reanalyzed at the third phrase to be subordinate. This reanalysis at the third phrase is affected by the working memory resources available because the prior NP two phrases had to be retrieved for reanalysis. If the magnitude of the late positivity was a manifestation of the working memory resources available for reanalysis, it would be smaller when the subordinate subject was a costly proper noun. Thus, the parietal-occipital positivity at the third phrase may be a manifestation of the reanalysis of the sentence-initial NP to be subordinate.

At the fourth phrases in scrambled order, we observed occipital negativity for Comp and Adjunct in the 400–500 ms time window and a significant late positivity only for Adjunct in the 600–800 ms time window. Establishing the verb-argument correspondence between the sentence-initial object and the subordinate verb was common for Comp and Adjunct, and the syntactic anomaly was peculiar to Adjunct in scrambled order. We also found a significant positive correlation between the peak latency of the positivity at several frontal electrodes and the individual grammatical judgment rate for the scrambled Adjunct sentences. We can, thus, understand the occipital negativity as a manifestation of the thematic correspondence between the preposed object and the subordinate verb, and the late positivity as a manifestation of the detection of a syntactic island violation. Figure 7 schematically shows the time course of the processing of our experimental sentences in scrambled order and the associated ERPs.

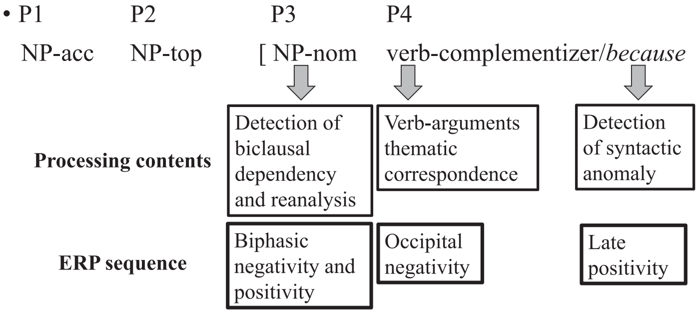

Figure 7: Event-related potential sequence in the processing of Japanese sentences with scrambled order and their processing contents.

The first research question was to examine the possible difference in neural activities between English and Japanese, as per their different head directions. We succeeded in the division of neural activities in a potential island construction in Japanese into several different aspects of processing. We observed four ERPs that could be confounded in the English counterparts. The second research question was to examine the correspondence between expected ERPs and the processing contents. As in Figure 7, the sequence of the four ERPs could be manifestations of the different processing in a possible island construction in Japanese. The third research question was to examine the possibility of attributing the relative weakness of the island effect in Japanese to its typological properties in sentence processing. In Japanese (potential) island constructions, the different aspects of the construction are processed sequentially. Specifically, the syntactic relationship between the discontinuous elements is computed with them received. In English island constructions, the relevant processes are performed simultaneously at the head with one of the discontinuous elements unreceived. The syntactic computation of a dependency with one of the two elements unknown is more costly than the computation with the two elements retained in working memory. The difference in the processing time course can, thus, be one of the reasons for the relatively weak island effect in Japanese.

4 Concluding remarks

We have discussed the processing of two types of complex sentences in Japanese, and we have succeeded in the examination of different aspects of the processing in detail that can be confounded in the counterparts in English. The experiment suggests that a comparative study on Japanese, which is agglutinate and head-final, is helpful to discuss the universality and peculiarity of sentence processing.

5 Limitations

We have succeeded in clarifying the time series of the processing of discontinuous dependency in Japanese, paying close attention to the difference in head direction between English and Japanese. However, we have not found the reason a syntactic island in English is associated with the LAN in some cases and the P600 in others. Researchers have been discussing what the P600 means (Van De Meerendonk et al. 2008; Brouwer et al. 2016; Brouwer and Crocker 2017). We should examine the generators of the linguistic ERPs because an ERP can be an overlap of multiple ERPs that are manifestations of neural activities in different brain regions. We should also discuss the connectivity between multiple brain regions because a mental function can be realized by the interaction in the network.

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Katsuo Tamaoka

Chapter 5
The time course of SOV and OSV sentence processing in Japanese

1 Introduction

As native speakers acquire their language, the mental lexicon is developed and stored in their brains. The process of retrieving the meaning of a certain item from the mental lexicon is called lexical access. Psycholinguists often refer to the syntactic operation system believed to exist in the brain as the *parser*. The time course of sentence formation depends on syntactic complexity and semantic context. Any transitive verb indicates what kind of subject phrase and object phrases are required for constructing a sentence. For example, the verb "eat" in the sentence "Tom ate an orange" provides information on the subject "Tom" as an actor and the object "an orange" as a thing to be eaten. This type of information provided by the verb is called *argument information.* A transitive sentence in the verb-final Japanese language has two basic orders: SOV or OSV (S is subject phrase, O object phrase and V verb). These arguments of noun phrases (NPs) are marked by one of three markers: two case markers of nominative -*ga* (NP_{NOM}) and accusative -*o* (NP_{ACC}) and one topic marker -*wa* (NP_{TOP}). These three markers construct four variations of SOV and OSV orders, as in sample sentences (1) to (4). All these sentences carry the same meaning of "(My) mother ate (an) apple." In this sentence, "mother" is understood as "my" mother unless otherwise specified. Moreover, there is no distinction between plural and singular or definite and indefinite articles for "apple." These four formats seem to be processed differently even though they carry the same or at least similar meanings. Thus, an examination of how these sentences are differently processed and the underlying factors is warranted.

(1) SOV canonical order

Haha	*ga*	*ringo*	*o*	*tabe*	*ta*
mother	NOM	apple	ACC	eat	PST

"(My) mother ate (an) apple."

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(2) OSV scrambled order

Ringo	*o*	*haha*	*ga*	*tabe*	*ta*
apple	ACC	mother	NOM	eat	PST

(3) Subject topicalized: the same order as SOV canonical

Haha	*wa*	*ringo*	*o*	*tabe*	*ta*
mother	TOP	apple	ACC	eat	PST

(4) Object topicalized: the same order as OSV scrambled

Ringo	*wa*	*haha*	*ga*	*tabe*	*ta*
apple	TOP	mother	NOM	eat	PST

Sentence (1) "(My) mother ate (an) apple" is in the order of "(my) mother," with nominative case marker -*ga* (NP_{NOM}), "(an) apple," with an accusative case marker -*o* (NP_{ACC}), and finally a past tense verb (V-PST) "ate." This sentence order is canonical in a transitive sentence. In sentence (2) the positions of NP_{NOM} and NP_{ACC} are scrambled, as is characteristic of the OSV order. Again, the final verb "ate" appears at the end of the sentence. A slowing in the speed of sentence processing for the scrambled OSV order relative to the canonical SOV order is frequently observed (e.g., Tamaoka et al. 2005; Tamaoka et al. 2014; Tamaoka and Mansbridge 2019). Thus, the first question (Question 1) arises as to why an OSV scrambled sentence requires additional processing time over a canonical SOV sentence. On this matter, it is also true that the scrambled distance becomes even longer in a ditransitive sentence (O_1SOt_1V; t is trace and O_1 is the originally placed t_1 position) relative to a transitive sentence ($O_1S\ t_1\ V$). A second question (Question 2) is then posed as to whether the scrambled distance affects the processing speed. If so, what is the factor responsible for it?

The verb appears at the end of all sentences from (1) to (4) and contains the argument information necessary to create a sentence structure. In Japanese, this information is only available at the end of the sentence. Thus, a native Japanese speaker cannot identify the cases of NPs required to construct a sentence until the final verb is seen. The third question (Question 3) of whether a verb-final language is disadvantageous for sentence processing subsequently emerges. Furthermore, if native Japanese speakers can process a sentence without the argument information provided by a verb, the question of the function of the final verb for Japanese sentence processing (Question 4) is warranted. This question can be further rephrased to ascertain whether there is any use for argument information in a verb-final language.

Noun phrases in Japanese are topicalized by the topic marker -*wa* (NP_{TOP}). The subject and object can be topicalized by the same topic marker. Sentence (3) is an example of a subject-topicalized ($NP_{SUB\text{-}TOP}$) sentence. This sentence is in the same order as the SOV canonical order. Subject topicalized sentence (3) starts with "Speaking of (my) mother." The subject topicalization also implies an exclusionary meaning, "mother," not other family members. Sentence (4) is an object topicalized ($NP_{OBJ\text{-}TOP}$) sentence. The object topicalization is in the same order as the OSV scrambled order. This sentence starts with "Speaking of (the) apple." This object topicalization also implies an exclusionary meaning, "(the) apple," not other fruits. Finally, the fifth question (Question 5) asks how topicalization affects sentence processing. It can be restated to be measurable as follows: Does a topicalized sentence require longer or shorter processing time than the equivalent non-topicalized sentence? This chapter discusses these five questions in-depth.

2 (Question 1): Why does an OSV scrambled sentence require more processing time than a canonical SOV sentence?

The processing speed and accuracy of Japanese sentences are often measured by a sentence correctness decision task using experimental software (e.g., E-prime, DMDX, PsychoPy). In this task, asterisks ******** indicating an eye-fixation point are presented at the center of a computer screen. Soon after (a 600 ms interval is often used), a stimulus sentence with semantically coherent and anomalous responses is presented to participants in random order. Participants are asked to decide whether the sentences are semantically acceptable by pressing a "Yes" or "No" button. They are also asked to answer as quickly as possible while maintaining accuracy. The task measures the elapsed time between the presentation of a sentence and the participant's subsequent response. This interval is called reaction (or processing) time. Thus, reaction time includes accessing lexical items, constructing a syntactic structure, understanding the meaning of the whole sentence, and finally making the decision.

The canonical order of SOV was found to be processed faster than the scrambled order of OSV in various psycholinguistic studies (e.g., Imamura, Sato and Koizumi 2016; Koizumi and Tamaoka 2004; Mazuka, Itoh, and Kondo 2002; Miyamoto 2006; Miyamoto and Takahashi 2004; Tamaoka et al. 2005; Tamaoka et al. 2014; Tamaoka and Mansbridge 2019; Ueno and Kluender 2003; Witzel and Witzel 2016). Tamaoka et al. (2005) used a sentence correctness decision task to measure the processing time for SOV and OSV sentences such as those presented in (1) and (2). The processing time of an SOV sentence is shorter than that of a scrambled OSV sentence (without any context). Japanese SOV sentences required 1,209 ms on average, while Japanese OSV scrambled sentences required 1,432 ms on average to process. The processing time difference between SOV and OSV sentences was 223 ms. The same trend occurred in processing accuracy for SOV sentences (M = 96.98%, M is the mean) over scrambled OSV sentences (M = 90.93%).

The scrambling effect describes the delay in processing time and more frequent inaccuracy for scrambled OSV-ordered sentences over their SOV canonical counterparts. The sentence processing model of *gap-filling parsing* (Frazier 1987; Frazier and Clifton 1989; Frazier and Flores D'Arcais 1989; Frazier and Rayner 1982; Stowe 1986) provides one possible explanation for the delay with the scrambled OSV order. This scrambling can be explained as a syntactic operation of phrasal movement from the original locus (t_1) of the object (NP_{ACC}-o_1) in the canonical position to the sentence-initial position as in $[_{CP}$ NP_{ACC}-o_1 $[_{IP}$ NP_{NOM}-ga $[_{VP}$ t_1 V]]], where IP is the inflectional phrase, and CP, complementizer phrase (or simply O_1S t_1 V). The t_1 (gap_1) indicates the original position in the canonical order from which the NP-o_1 was moved to the sentence-initial position.

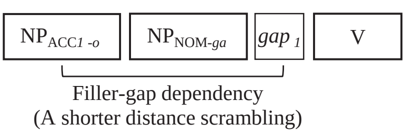

Figure 1: The filler-gap dependency in a transitive sentence (O_1S t_1 V).

From Figure 1, to accomplish the processing of a scrambled sentence, native Japanese speakers must recognize the initial NP_{ACC}-o_1 as the filler and find its original position in VP (gap_1) to establish the filler-gap dependency. Here, given the degree of syntactic complexity, a canonical SOV-ordered sentence is expected to be processed more quickly than its OSV-ordered scrambled counterpart (O_1S t_1 V).

3 (Question 2): Does longer-distance scrambling require longer processing time than shorter-distance scrambling?

From Figure 1, the scrambled distance in a transitive sentence (O_1S t_1 V) comprises only the subject NP_{NOM} (S) between the filler (O_1) and the gap (t_1). It is called shorter-distance scrambling. For longer-distance scrambling (Tamaoka et al. 2005), a ditransitive sentence is used to measure the effect of scrambled distance. When the original locus of the object (NP-*o*, *hon-o* “(a) book”) in the canonical position of sentence (5) is moved to the sentence-initial position, as in sentence (6), the scrambled distance comprises the two NPs of NP_{NOM} (S) and NP_{DAT} (O) between the filler (O_1) and the gap (t_1). This scrambling is denoted as O_1 S O t_1 V.

(5) SOOV canonical order

Hanako	*ga*	*Taro*	*ni*	*hon*	*o*	*kaesi*	*ta*
Hanako	NOM	Taro	DAT	book	ACC	return	PST

“Hanako returned to Taro (a) book.”

(6) O_1 S O t_1 V scrambled order

Hon	*o*	*Hanako*	*ga*	*Taro*	*ni*	*kaesi*	*ta*
book	ACC	Hanako	NOM	Taro	DAT	return	PST

From Figure 2, the gap_1 in O_1 S O t_1 V (t_1 is equal to gap_1) shows the original position in the canonical SOOV order from which the NP_{ACC}-o_1 was moved to the sentence-initial position. Native Japanese speakers must recognize the initial NP_{ACC}-o_1 as the filler and find its original position in gap_1 to establish the filler-gap dependency and process the scrambled sentence. Relative to the transitive sentence in Figure 1, the scrambling in a ditransitive sentence in Figure 2 can be considered a longer-distance scrambling. The effect of the scrambled distance on processing can be probed by comparing the difference in the scrambling effect between transitive and ditransitive sentences.

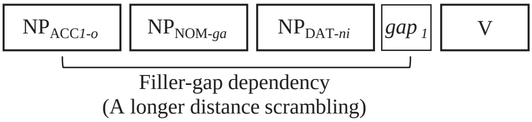

Figure 2: The filler-gap dependency in a ditransitive sentence (O_1S O t_1 V).

Figure 3 shows the processing speed results for shorter- and longer-distance scrambling in (di)transitive sentences. As noted, Tamaoka et al. (2005) report that the difference in the processing time of a transitive sentence between SOV and O_1 S t_1 V (i.e., the shorter-distance scrambling effect) orders was 223 ms. They show that canonical SOOV ditransitive sentences required 1,359 ms on average, while the corresponding O_1S O t_1 V scrambled sentences required 1,963 ms on average. The difference in processing time (i.e., the longer-distance scrambling effect) was 604 ms. Thus, the difference in the scrambling effect between shorter- and longer-distance scrambling was 381 ms (604 ms – 223 ms). The magnitude of the scrambling effect was large even though the scrambled distance differed by only a single NP between transitive and ditransitive sentences.

Further, the percentage difference in processing accuracy between an SOV and an O_1 S t_1 V transitive sentence was 6.05%, while the difference in the accuracy between an SOOV and an O_1 S O t_1 V ditransitive sentence was 10.00%. The difference in the accuracy of the scrambled effect between transitive and ditransitive sentences was 3.95% (10.00% − 6.05%). Relative to shorter-distance scrambling, longer-distance scrambling was more challenging to accurately process. Thus, the scrambled distance caused a larger delay in reaction times and a higher rate of errors, even with a single NP difference.

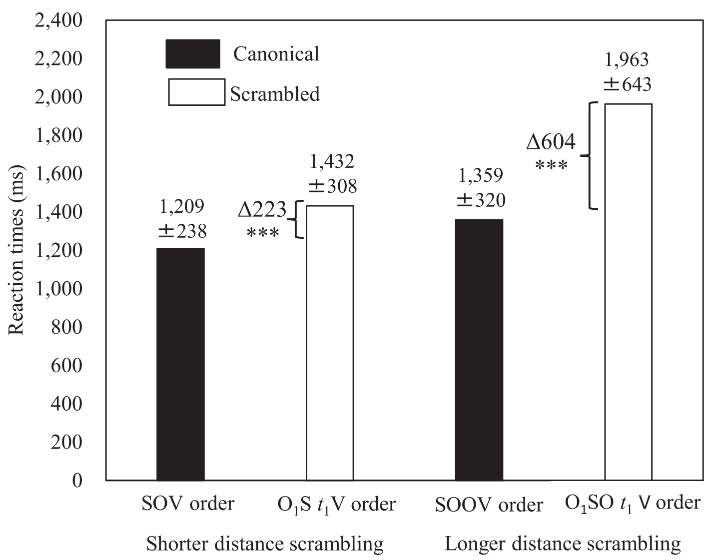

Figure 3: The scrambling effect of shorter- and longer-distance scrambling.
Note: *** *p*<.001. Δ is the scrambling effect and ± is a standard division.

In Tamaoka et al. (2005), canonical SOV or SOOV sentences were re-arranged into scrambled OSV or OSOV orders, respectively, such that each pair of canonical and scrambled sentences carried the same meaning. Moreover, SOV-OSV and SOOV-OSOV conditions were presented under the same experimental condition, where no previous contextual information was given to native Japanese speakers for the sentence correctness decision task. One weakness may have been that the comparison in differences in the scrambling effect between the shorter SOV-OSV and longer SOOV-OSOV scrambling distances emerged from sentences not being semantically identical. The difference between the shorter and longer scrambling distance was, however, large at 381 ms in speed and 3.95% in accuracy. As Tamaoka et al. (2005) used the simplest syntactic structures of sentences to probe the scrambling effect, the distance effect in scrambling seems to exist as an inhibitory effect in sentence processing. This effect may stem from the distance difference in the filler-gap dependency for performing the gap-filling parsing, as in Figures 1 and 2 for shorter and longer-distance scrambling, respectively.

4 (Question 3): Is a head (verb) final language disadvantageous for sentence formation?

Head-driven parsing (Pritchett 1988, 1991, 1992) suggests that syntactic phrasal structures are established by the head verb that provides necessary argument information for the construction of a sentence (Ikuta et al. 2009; Wolff et al. 2008). According to this processing model, understanding the information provided by the verb is the key to sentence formation. The head-driven parsing model applies best to English and other European languages. However, when the model is extended to other languages, it raises an additional question: are head- (verb)-final languages, such as Japanese and Korean, disadvantageous for sentence formation, unlike head- (verb)-initial languages, such as Kaqchikel and Tongan?

Regarding the head-final language of Japanese, the transitive verb "eat" provides information for the two arguments of the agent "(my) mother" with a nominative case marker ($NP_{NOM\text{-}ga}$) and the theme "(an) apple" with an accusative case marker ($NP_{ACC\text{-}o}$) in sentence (1). The two NPs are linked by the verb "eat." However, as the verb is at the end of the sentence, argument information cannot be utilized by native Japanese speakers. One can follow the two NPs with other verbs, such as "buy," "wash," and "cook." According to the head-driven parsing model, the verb-final position required for a head-final language causes confusion among native speakers, which may explain the delay in sentence processing. However, in such a situation, native Japanese speakers can combine the two NPs to get a head start on processing the whole sentence until the final verb "eat" becomes available.

By contrast, when the head-driven parsing model is applied to verb-initial languages, such as many Austronesian (e.g., Tagalog, Hawaiian, and Tongan) and Mayan (e.g., Kaqchikel, Tz'utujil, and Achi) languages, a great advantage is expected in processing sentences. Native speakers of these languages obtain the argument information from the verb at the beginning of a sentence and can easily process a whole sentence based on argument information. Thus, a distinct difference in reaction time is observed between a verb-initial language and a verb-final language: a sentence of a verb-initial language is processed much faster than an equivalent sentence of a verb-final language.

Koizumi et al. (2014) document reaction times for transitive sentences in canonical VOS and scrambled VSO orders in the verb-initial Kaqchikel language. Sentences with two NPs and a single verb in Kaqchikel transitive sentences may be considered equivalent in constituent elements to a Japanese transitive sentence. The mean reaction times for canonical and scrambled orders in both languages are comparable in cognitive load for sentence processing. As in Figure 4, processing of canonical VOS sentences in Kaqchikel took 3,403 ms on average (89.39% of accuracy) while scrambled VSO sentences took 3,601 ms on average (77.10% of accuracy). The scrambling effect measured 198 ms (3,601 ms in VOS – 3,403 ms SOV). The magnitude of the scrambling effect in Kaqchikel was similar to that of Japanese at 223 ms.

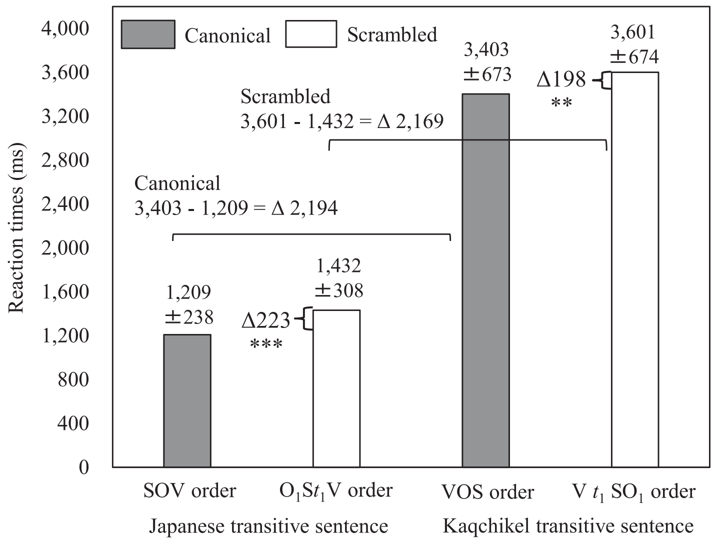

Figure 4: The scrambling effect in transitive sentences in Japanese (visual presentation) and Kaqchikel (auditory presentation).
Note: ** *p*<.01. *** *p*<.001. ± is the standard division.
Δ is the difference in the scrambling effect.

Since Kaqchikel sentences were auditorily presented, reaction times include the length of time for pronouncing a whole sentence. Thus, longer decision times for sentences were expected. The difference in the average reaction times for processing whole transitive sentences in the canonical (or basic word order) was large at 2,194 ms (3,403 ms in Kaqchikel VOS – 1,209 ms Japanese SOV). Moreover, the difference for transitive sentences in scrambled order was also large at 2,169 ms (3,601 ms in Kaqchikel VSO – 1,432 ms Japanese OSV). This difference in reaction times between Japanese and Kaqchikel stemmed from the different presentation methods used for the experiments: visual (auditory) presentation in Japanese (Kaqchikel). Considering that the overall average duration of an auditory presented Kaqchikel sentence is approximately 2,100 ms, native Japanese and Kaqchikel speakers are likely to process sentences at near equivalent times. Likewise, as in Figure 4, the magnitude of the scrambling effect was similar at 223 (198) ms for Japanese (Kaqchikel). Thus, the result does not support the existence of an advantage in sentence processing time in the verb-initial (-final) language of Kaqchikel (Japanese). Japanese and Kaqchikel seem to have similar processing times for canonical and scrambled sentences.

Given that Kaqchikel is a unique language in that the object precedes the subject in its VOS basic word order, examining another head-final Austronesian language, such as Tongan, may add more data useful for analyzing the scrambling effect. In Tongan, VSO is the canonical order of transitive sentences, while VOS is also grammatically possible as a scrambled order sentence (Churchward 1953; Custis 2004; Dixon 1979, 1994; Otsuka 2000, 2005a, 2005b). During a sentence correctness decision task, native speakers of the verb-initial Tongan language were observed to process simple transitive sentences, such as "The woman ate the fish." The result showed an average speed of 1,643 ms for the VSO canonical order and 1,753 ms for VOS scrambled order (data yet to be published). The difference in speed was 110 ms (significant at 0.001 level). Although the magnitude of the scrambling effect was much smaller than that for Japanese and Kaqchikel, the scrambling effect was still apparent in Tongan.

Regarding Kaqchikel and Tongan, there is no advantage evidence in the processing of head- versus verb-initial language sentences. Therefore, the verb-initial order cannot be considered advantageous in sentence processing. The head-driven parsing model may be a good fit for English and other European languages. However, the head-final language of Japanese seems to rely on features other than verb information for advantageous sentence processing. Notably, Tamaoka and Mansbridge (2019) show that the argument information provided by the verb is an important factor for processing a sentence in Japanese. This factor will be introduced in the following section.

5 (Question 4): What function does a finally positioned verb have for sentence processing?

If the verb-initial position is not advantageous for sentence processing, how is a sentence in the verb-final language of Japanese processed? Kamide and Mitchell (1999) and Kamide, Altmann, and Haywood (2003) provided evidence for pre-head processing using the "visual-world" eye-tracking paradigm. In this paradigm, multiple pictorial items are presented on a single screen, some of which regard a sentence that is auditorily presented. Participants look at this screen for approximately one second. A sentence is then auditorily presented and the sequential duration of eye-fixation times is recorded by the eye-tracker. Kamide and Mitchell (1999) and Kamide, Altmann and Haywoodet (2003) find that participants were likely to focus on pictorial items on the screen, which had not yet been auditorily presented. Accordingly, Kamide and Mitchell (1999) suggested that advance planning for comprehending sentences occurs incrementally before the final verb is seen. Native Japanese speakers can anticipate the formation of a sentence based on the argument information provided by the NPs' case markers.

Figure 5 shows the processing sequence of the Japanese SOV sentence (1). Native Japanese speakers see or hear the agent *haha-ga* "(my) mother" first. They can identify the subject phrase by referring to the nominative case marker *-ga* ($NP_{NOM\text{-}ga}$). At this stage, native Japanese speakers already know that "(my) mother" is the actor. Next, the theme *ringo-o* "(an) apple" with the accusative case marker ($NP_{ACC\text{-}o}$) follows. By relying on these case markers, native Japanese speakers can begin to form a sentence containing two NPs, as in $[_{IP}$ NP(mother)$_{NOM\text{-}ga}$ $[_{VP}$ NP(apple)$_{ACC\text{-}o}$. . .]]. Then, they simply wait for the ending verb *tabe-ta* "ate" to complete the sentence. Thus, for pre-head anticipatory processing (Kamide and Mitchell 1999; Kamide, Altmann and Haywoodet 2003; also see Kamide 2008; Altmann and Kamide 1999 for general discussion), the first part of a Japanese sentence is formed before seeing the ending verb.

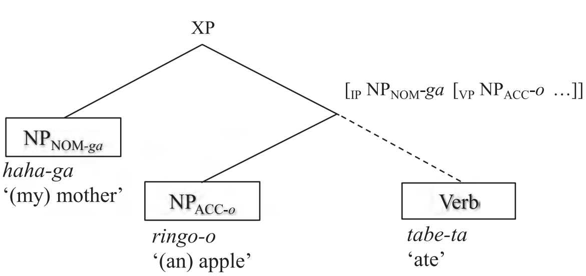

Figure 5: Pre-head anticipatory sentence processing based on case markers.

If anticipatory processing takes place as Kamide et al. (1999, 2003) describe, one may wonder whether a Japanese verb has any role in sentence processing. An eye-tracking study by Tamaoka and Mansbridge (2019) shows that even a simple transitive sentence with a shorter-distance scrambling, as in Figure 1, involves pre-head anticipatory processing (Kamide 2008; Kamide and Mitchell 1999; Kamide, Altmann, and Haywood 2003) and head-driven processing (Pritchett 1988, 1991, 1992). Tamaoka and Mansbridge (2019) employ a set of sentences (7) and (8) to investigate the mechanism of processing. Note that sentence (8) is not the exact equivalent of the scrambled ordered sentence (7). Ideally, for measuring eye-fixation times in each region, the words of paired canonical and scrambled sentences should be as similar as possible. For instance, the only difference in the NP in Region 1 was the single case marked *Taro, -ga* in sentence (7) and *-o* in sentence (8). Similarly, Region 2 was controlled such that the only difference was the case marked *Hanako, -o* in sentence (7) and *-ga* in sentence (8). The ending verb *syootaisi-ta* "invited" was retained. Eye-fixation durations and regression-in and -out frequencies in each region were recorded using the EyeLink 1000 Core System (SR Research Ltd., Ontario, Canada) for whole sentence reading by native Japanese speakers.

(7) SOV canonical order

Region 1		Region 2		Region 3	
Taro	*ga*	*Hanako*	*o*	*syootaisi*	*ta*
Taro	NOM	Hanako	ACC	invite	PST

"Taro invited Hanako."

(8) O_1 S t_1 V scrambled order

Region 1		Region 2		Region 3	
Taro	*o*	*Hanako*	*ga*	*syootaisi*	*ta*
Taro	ACC	Hanako	NOM	Invite	PST

The results of processing transitive sentences in Figure 6 are recorded in milliseconds, with Δ indicating differences in fixation times between O_1 S t_1 V and SOV transitive sentences. Processing times for canonical ordered sentences were subtracted from those for scrambled ordered sentences. The involvement of pre-head anticipatory processing (e.g., Aoshima, Phillips, and Weinberg 2004; Aoshima, Yoshida, and Phillips 2009; Kamide 2008; Kamide and Mitchell 1999; Kamide, Altmann and Haywoodet 2003; Miyamoto 2006; Mazuka, Itoh and Kondo 2002; Witzel and Witzel 2016) indicated a significantly longer "go-past time" of Δ 129 ms in Region 2 before the verb appears (see details of eye-tracking measurements in Tamaoka and Mansbridge 2019). The ending verb in Region 3 also received a significantly longer go-past time of Δ 140ms.

Additionally, evidence of heavy head-driven processing (Ikuta et al. 2009; Wolff et al. 2008) was seen in the re-reading time of Δ147 ms in Region 2. Given that the gap_1 (or t_1) in O_1 S t_1 V scrambled sentences is found between $NP_{NOM\text{-}ga}$ (S) in Region 2 and the head verb (V) in Region 3, the significantly longer re-reading time suggested that native Japanese speakers read back to the crucial $NP_{NOM\text{-}ga}$ in Region 2 to check the argument structure of $NP_{NOM\text{-}ga}$ and $NP_{ACC\text{-}o}$ after seeing the head verb. This trend was further supported by the occurrence of significantly higher regression-in frequency of Δ 13% for O_1 S t_1 V scrambled sentences in Region 2 from the ending verb.

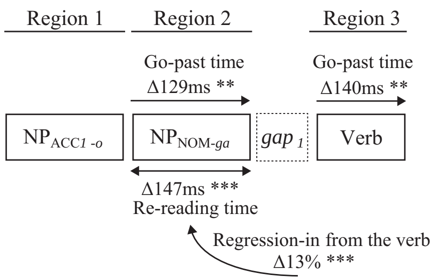

Figure 6: Processing of scrambled transitive sentences observed by eye-tracking.
Note: ** p<.01. *** p<.001. Δ (ms) is a difference in fixation time (O_1 S t_1 V – SOV).

In summary, a scrambled $NP_{ACC\text{-}o}$ and $NP_{NOM\text{-}ga}$ order trigger pre-head anticipatory processing to form a partial sentence structure. However, commonly-used individuals' first names as two NPs do not provide sufficient information to establish the filler-gap dependency. The O_1 S t_1 V sentence was most often read up to the head verb and then read back to the crucial $NP_{NOM\text{-}ga.}$ Evidence of reading backward from the ending verb to Region 2 and re-reading times in Region 2, as observed by Tamaoka and Mansbridge (2019), suggests that native Japanese speakers require the argument information provided by the verb to resolve the filler-gap dependency of scrambling even in simple transitive sentences.

Processing scrambled sentences was further probed in complex sentences comprising three NPs and two verbs in the [S [SOV] V] format. Tamaoka and Mansbridge (2019) embedded the stimulus sets in sentences such as (7) and (8) into complex sentences, as in sentences such as (9) and (10). Again, sentence (10) is not based exactly on sentence (9). However, a direct comparison of eye fixations and regression-in and -out in an eye-tracking study requires only that the same noun is used in each Region. In sentence (10), the filler O_1 or $NP_{ACC\text{-}o1}$ was moved from the original locus of the embedded sentence (t_1) to the sentence-initial position of Region 1 as ([O_1 S [S t_1 V] V]). Notably, Tamaoka and Mansbridge (2019) used short-distance scrambling in complex sentences. However, an analysis of that condition is omitted here to simplify the discussion.

(9) [S [SOV] V] canonical order

Region 1		Region 2		Region 3		Region 4	
Kenji	*ga*	*Taro*	*ga*	*Hanako*	*o*	*syootaisi*	*ta*
Kenji	NOM	Taro	NOM	Hanako	ACC	invite	PST

Region 5		
to	*kii*	*ta*
COMP	hear	PST

"Kenji heard that Masato helped Keiko."

(10) [O_1 S [S t_1 V] V] scrambled order

Region 1		Region 2		Region 3		Region 4	
Kenji	*o*	*Taro*	*ga*	*Hanako*	*ga*	*syootaisi*	*ta*
Kenji	ACC	Taro	NOM	Hanako	ACC	invite	PST

Region 5		
to	*kii*	*ta*
COMP	hear	PST

The results of complex sentence processing, measured by eye tracking, as in Figure 7, are recorded in milliseconds, with Δ indicating differences in fixation times between canonical sentences [S [S O V] V] and scrambled sentences [O_1 S [S t_1 V] V]. Processing times for canonical ordered sentences were subtracted from those for scrambled ordered sentences. The initial NP_{ACC1} in Region 1 had no significant go-past time. The second NP_{NOM} had a significant go-past time (Δ49 ms). As for Kamide et al. (1999, 2003), the OS order or the *o*-and-*ga* order in Regions 1 and 2 can provide the initial basis for a partially constructed phrasal structure [$_{IP}$ $NP_{NOM\text{-}ga}$ [$_{VP}$ $NP_{ACC\text{-}o}$ . . .]]. At the early processing stage (i.e., go-past time), there was no extra processing in Region 3 for a scrambled sentence. Commonly-used individuals' first names as the three NPs do not provide sufficient information to establish the filler-gap dependency. Thus, native Japanese speakers read ahead until they reach the subsequent two verbs: the verb in the subordinate clause in Region 4 (Δ739 ms) and that in the main clause in Region 5 (Δ1,147 ms). Eye fixation on these two verbs lasted much longer than on their corresponding complex sentences, as in Figure 7. At the later stage of processing, re-reading time and regression-in were highly significant in multiple Regions of complex sentences. These significant re-reading times were seen in all three NPs; $NP_{ACC\text{-}o}$ in Region 1 (Δ292 ms), $NP_{NOM\text{-}ga}$ in Region 2 (Δ256 ms), and $NP_{NOM\text{-}ga}$ in Region 3 (Δ369 ms). After obtaining argument information from the verbs in the subordinate and main clauses, native Japanese speakers read back to all three NPs to properly form the noun phrase structure. Given that significant re-reading times were observed in Region 4 (Δ171 ms), this pattern is especially salient in cases where the verb is seen in the subordinate clause. This trend was also seen in the significant frequencies of regression-in into $NP_{ACC\text{-}o}$ in Region 1 (Δ24%) and $NP_{NOM\text{-}ga}$ in Region 3 (Δ19%).

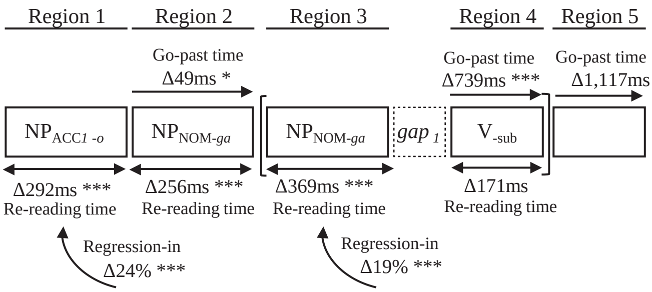

Figure 7: Processing of a scrambled complex sentence measured by eye-tracking.
Note: * $p<.05$. *** $p<.001$. Δ (ms) is the difference in fixation times while Δ (%) is the difference in frequencies of regression-in. The differences were calculated by subtracting the processing time for the canonical order [S [SOV] V] from that of the scrambled order [O_1 S [S t_1 V] V] in each region.

As Kamide et al. (1999, 2003) have proposed, pre-head anticipatory processing is observed in head-final languages, such as Japanese. Furthermore, an eye-tracking study by Tamaoka and Mansbridge (2019) showed longer go-past times for verbs and re-reading times in all three NPs. Regression-in to $NP_{NOM\text{-}ga}$ was found in simple transitive and complex sentences. Native Japanese speakers must establish a relationship between the filler $NP_{ACC\text{-}o1}$ and the *gap*$_1$ after obtaining argument information given by the verb to perform gap-filling parsing. Thus, depending on the availability of processing cues, native Japanese speakers must perform pre-head and head-driven (post-head) processing for scrambled sentences.

6 (Question 5): How does the nature of topicalization affect sentence processing?

Topicalization in Japanese is produced by the topic marker -*wa*. The subject and the object can be topicalized, as shown by the subject topicalization ($NP_{SUB\text{-}TOP}$) in sentence (3) and the object topicalization ($NP_{OBJ\text{-}TOP}$) in sentence (4). A topicalized phrase is usually positioned at the beginning of a sentence. When a topicalized NP is placed in the second or even later position, the sentence becomes less acceptable. This phenomenon warrants further investigation via a simple questionnaire survey of naturalness judgments.

Shibatani (1990) proposed that $NP_{SUB\text{-}TOP}$ of transitive sentences ($S_{TOP}O_{ACC}V$) are external to the IP in $[_{CP}\ NP_{SUB\text{-}TOP1}\ [_{IP}\ t_1\ [_{VP}\ NP_{ACC}\ V]]]$. In this structure, $NP_{SUB\text{-}TOP}$ belongs to a CP, placed structurally higher than the IP. If true, $S_{TOP}O_{ACC}V$ will be more complex in syntactic structure than $S_{NOM}O_{ACC}V$. The difference in structural complexity predicts that $S_{TOP}O_{ACC}V$ sentence processing will take longer than $S_{NOM}\ O_{ACC}V$ sentence processing. Moreover, since $S_{TOP}O_{ACC}V$ involves only a topicalized movement, which does not move beyond any NP, the scrambled $O_{ACC}S_{NOM}V$ order is anticipated to take longer to process than the $S_{TOP}O_{ACC}V$ order. Moreover, the order of an object topicalized ($NP_{OBJ\text{-}TOP}$) transitive sentence is $O_{TOP}S_{NOM}V$, which is the same order as the scrambled order of $O_{ACC}S_{NOM}V$. Kuroda (1987) further proposed that $NP_{OBJ\text{-}TOP}$ involves a topicalization movement and a scrambling movement. Because $NP_{OBJ\text{-}TOP}$ involves movements of both topicalization and scrambling, sentence structure becomes even more complex than the scrambled $O_{ACC}S_{NOM}V$. This difference in structural complexity yields a prediction that $O_{TOP}S_{NOM}V$ will require longer processing time than will $O_{ACC}S_{NOM}V$. As for the discussion of syntactic structure (Kuroda 1987; Shibatani 1990), Imamura, Sato and Koizumi (2016) hypothesized the following order in sentence processing speed.

$S_{NOM}O_{ACC}V$	=	$S_{TOP}O_{ACC}V$	<	$O_{ACC}S_{NOM}V$	<	$O_{TOP}S_{NOM}V$
Canonical		Topicalizatio		Scrambled		Topicalization and Scrambled

Figure 8: Assumed order of sentence processing speed based on syntactic complexity.
Note: Reproduced from Imamura, Sato and Koizumi 2016, p. 5.

Imamura, Sato and Koizumi (2016, Experiment 1) created four types of sentences exemplified in sentences (11) to (14) to confirm the hypothesized order of sentence processing in Figure 8. These stimulus sentences used commonly-used family names such as Sato, Suzuki, Iida, and Hirota. The family names were used interchangeably between the subject (e.g., *Suzuki-ga*) and object (e.g., *Suzuki-o*). In this situation, native Japanese speakers could not utilize semantic cues of animacy contrast, such as "(my) mother" and "(an) apple" to construct a partial sentence structure before seeing the ending verb.

(11) $S_{NOM}\ O_{ACC}$ V: Canonical order

Satoo	*ga*	*Suzuki*	*o*	*home*	*ta*
Sato	NOM	Suzuki	ACC	praise	PST

"Sato praised Suzuki."

(12) S_{TOP} O_{ACC} V: Subject topicalized order

Satoo	*wa*	*Suzuki*	*o*	*home*	*ta*
Sato	TOP	Suzuki	ACC	praise	PST

(13) O_{ACC} S_{NOM} V: Scrambled order

Suzuki	*o*	*Satoo*	*ga*	*home*	*ta*
Suzuki	ACC	Sato	ACC	praise	PST

(14) O_{TOP} S_{NOM} V: Object topicalized order

Suzuki	*wa*	*Satoo*	*ga*	*home*	*ta*
Suzuki	TOP	Sato	ACC	praise	PST

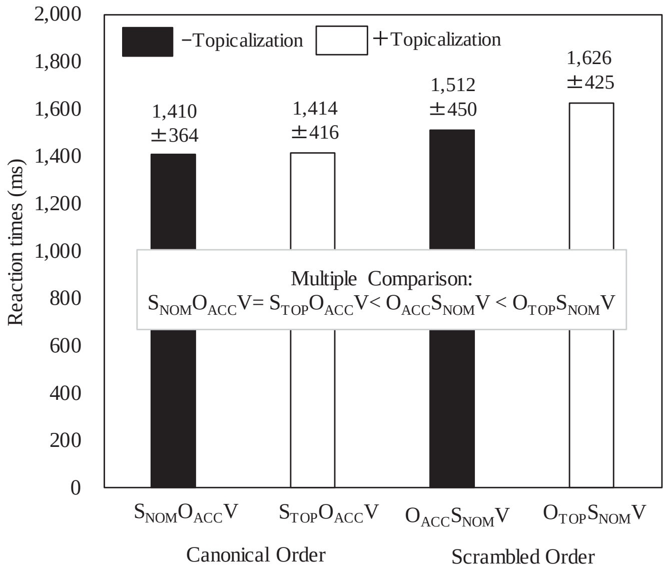

Figure 9: Processing topicalized sentences with canonical and scrambled orders.
Note: ± is the standard division. Taken from Imamura, Sato and Koizumi 2016, p. 6.

Using a sentence correctness decision task, Imamura, Sato and Koizumi (2016) presented whole sentences to participants who were asked to decide whether the sentences were syntactically and semantically correct. Given that the four types of sentences presented in this part of the study contained the same constituent elements of nouns and verbs, reaction times were directly comparable. Figure 9 shows the means of sentence processing speeds in Imamura, Sato and Koizumi (2016). There was a difference of only 4 ms in processing speed between the canonical $S_{NOM}O_{ACC}V$ (M = 1,410 ms, M refers to the mean reaction time) and the subject topicalized $S_{TOP}O_{ACC}V$ (M = 1,414 ms) sentences. Given no difference in processing time between the canonical $S_{NOM}O_{ACC}V$ and the subject topicalized $S_{TOP}O_{ACC}V$ sentences, the syntactic structure with movement, as proposed by Shibatani (1990) and Kuroda (1987), may not represent the "psychological reality" of sentence processing. This result implies that subject topicalization may occur without any movement. Imamura, Sato and Koizumi (2016) explain that $S_{NOM}O_{ACC}V$ and $S_{TOP}O_{ACC}V$ would be processed as the SOV canonical order.

The overall scrambling effect between $S_{NOM}O_{ACC}V$ plus $S_{TOP}O_{ACC}V$ (the mean of both conditions was M = 1,412 ms) and $O_{ACC}S_{NOM}V$ plus $O_{TOP}S_{NOM}V$ (the mean of both conditions was M = 1,569 ms) was significantly greater at 157 ms. Thus, the scrambling effect accords with previous studies (e.g., Koizumi and Tamaoka 2004, 2010; Mazuka, Itoh and Kondo 2002; Miyamoto and Takahashi 2004; Tamaoka et al. 2005; Tamaoka, et al. 2014; Ueno and Kluender 2003).

The topicalized object sentences $O_{TOP}S_{NOM}V$ (M = 1,626 ms) took significantly longer to process than did the scrambled sentences $O_{ACC}S_{NOM}V$ (M = 1,512 ms). The increasing order of processing speed of $S_{NOM}O_{ACC}V < O_{ACC}S_{NOM}V < O_{TOP}S_{NOM}V$ may be accounted for by syntactic complexity. In any case, Imamura, Sato and Koizumi (2016) discount Shibatani's (1990) topicalization movement proposal for $S_{TOP}O_{ACC}V$. If topicalization does not involve any movement, $O_{TOP}S_{NOM}V$ may involve only a single movement of scrambling: $O_{TOP}S_{NOM}V$ takes on the same structure as $O_{ACC}S_{NOM}V$. Thus, no difference in processing speed between $O_{ACC}S_{NOM}V$ and $O_{TOP}S_{NOM}V$ should have been found in their experiment. Nevertheless, the results indicated that $O_{TOP}S_{NOM}V$ took longer to process than $O_{ACC}S_{NOM}V$. Hence, this result supports the idea of double movements of scrambling and topicalization proposed by Kuroda (1987).

Recapping the processing result of Imamura, Sato and Koizumi (2016), the subject topicalized word order of $S_{TOP}O_{ACC}V$ is the same as that of the canonical $S_{NOM}O_{ACC}V$. Thus, as Imamura, Sato and Koizumi (2016) suggest, this order seems to be commonly used such that the structures of $S_{NOM}O_{ACC}V$ and $S_{TOP}O_{ACC}V$ are easily understood within a short processing time. A simple explanation could be that the use of the topic marker -*wa* in the SOV order by native Japanese speakers is interpreted as forming the subject with the topicalized NP-*wa*. Stimulus sentences by Imamura, Sato and Koizumi (2016) using two family names included an example of subject topicalization (S_{TOP}) in the sentence *Sato-wa Suzuki-o hometa*. On reading the name Sato, it is understood that no other actor praised Suzuki. This exclusionary meaning may not function well for S_{TOP} and may also explain the lack of processing time difference between $S_{NOM}O_{ACC}V$ and $S_{TOP}O_{ACC}V$. The lesser degree of interpretability for the exclusionary meaning makes it easier to understand S_{NOM} and S_{TOP} as simply the subjects of a sentence.

Conversely, with the object topicalization (O_{TOP}) of *Sato-wa Suzuki-ga hometa*, Sato is the recipient of praise from the actor Suzuki. In this sentence, the recipient object Sato is placed at the beginning of the sentence by topicalization. However, this placement also stems from scrambling movement. By topicalizing the object Sato, it is probably easier to understand the exclusionary meaning. Among the group who could be praised, only Sato was praised by Suzuki. This semantic processing may require longer processing time than does the scrambled $O_{ACC}S_{NOM}V$. Consequently, the degree of ease for exclusionary interpretation by the topic marker *-wa* could be an additional factor in the resultant extra processing load for the object topicalized $O_{TOP}S_{NOM}V$.

The Japanese topic marker *-wa* appears to have dual functions of sentence-initial topicalization and exclusionary focus. As for Imamura, Sato and Koizumi (2016), future studies should clarify the exclusionary function of the Japanese topic marker *-wa*. Proof of a clear exclusionary meaning could be established by using sentences with animacy contrast. For example, sentence (3) *haha-wa ringo-o tabe-ta* has clear animacy contrast in that "my mother," not any other family member, ate an apple. In object topicalization, the focus is on "an apple," not any other fruits, which my mother ate. The function of the topic marker *-wa* could be clarified by setting a clear exclusionary meaning in a sentence.

Further, to avoid interference from canonical and scrambled word orders in identifying topicalization in the Japanese language, it would be advisable to use other VSO-ordered languages, such as Tagalog, Hawaiian, and Tongan for comparison. For example, the canonical order of the Tongan language is VSO (Churchward 1953; Custis 2004; Dixon 1979, 1994; Otsuka 2000, 2005a, 2005b). As with the Japanese language, the subject and object may be topicalized. When the subject is topicalized, S_{TOP} is placed before the verb as SVO. Native Tongan speakers also perceive the topic of the sentence "mother" signifies that it was not any other family member who ate an apple. When the object is topicalized, O_{TOP} is placed before the verb as OVS, signifying that it was "an apple," not any other fruit, the mother ate. The topicalized NP is placed before the verb as SVO or OVS. Thus, the word order of topicalization in the Tongan language does not overlap with either canonical or scrambled orders in Japanese. Hence, a verb-initial language such as Tongan is ideal for probing the processing function of topicalization.

7 Closing remarks

The question of how SOV and OSV transitive sentences in Japanese are processed can be summarized as follows: The SOV order is the basic structure for sentence processing in Japanese. An OSV scrambled sentence is processed using gap-filling parsing (establishing the filler-and-gap dependency). Even though pre-head anticipatory processing will function before the final verb appears, head-driven processing (verb argument information) is also required, especially for processing an OSV scrambled ordered sentence. Topicalization of a Japanese subject marked by *-wa* has a dual function of stating the topic at the beginning of the sentence and adding an exclusionary meaning. Nevertheless, as subject topicalization uses the same word order as the canonical SOV, a topicalized noun phrase may be interpreted as being the subject, as is an NP marked by the nominative case marker *-ga*. It applies all the more so when there is no clear semantic distinction between the subject and the object. By contrast, object topicalization is understood as sentence-context topicalization and exclusionary-semantic focus. The processing of the dual functions of topic marker *-wa* may explain the longer processing time required over the OSV scrambled order. Future studies can probe Japanese sentence processing by comparing Japanese to languages with different canonical orders, especially verb-initial languages, such as Tongan in which subject-object topicalized order does not overlap with canonical or scrambled order.

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Chapter 6
Sentence processing cost caused by word order and context: Some considerations regarding the functional significance of P600

1 Introduction

In the field of psycholinguistics, sentence comprehension is a topic of great interest (Miyamoto 2008; Koizumi 2015). Experiments using event-related brain potentials (ERPs) are often utilized as a research method to explore this topic (Sakamoto 2015). Among the ERP components, P600 is often used as an indicator of sentence-processing load (Coulson, King, and Kutas 1998; Friederici, Pfeifer, and Hahne 1993; Osterhout and Holcomb 1992; Osterhout and Mobley 1995; Hagoort, Brown, and Groothusen 1993; Hagoort, Brown, and Osterhout 1999; Kaan and Swaab 2003a, 2003b). However, recent studies show various interpretations of the functional significance of P600. They suggest that the type of cognitive process the P600 reflects as an ERP component remains a matter of debate. This study conducts a preliminary examination of how the pattern of P600 for the processing load of scrambled sentences changes per context (i.e., line drawings presented to the participants). Based on the results of this experiment, we aim to share materials to study the functional significance of P600.

As many cognitive neuroscientists know, ERPs are negative and positive voltage changes in the ongoing electroencephalogram (EEG) that are time-locked to the onset of a cognitive event. P600 is an ERP effect that shows a positive peak around 600 milliseconds (ms) after the onset of a stimulus. Given that the effects were first reported in the early 1990s, P600 has been considered an ERP component that

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reflects the process of detecting or correcting syntactic anomalies (Osterhout and Holcomb 1992; Hagoort et al. 1993). However, several subsequent studies report that ungrammatical sentences produce a P600 effect, and grammatical sentences are structurally complex or (temporarily) ambiguous. Moreover, there have been reports of a “semantic P600” effect that occurs in sentences containing inappropriate semantic roles without grammatical anomalies (Bornkessel-Schlesewsky and Schlesewsky 2008; Hoeks, Stowe, and Doedens 2004; Kim and Osterhout 2005; Kim and Sikos 2011; Kuperberg et al. 2003, 2006, 2007). As reported by Vissers et al. (2008), for example, P600 is observed for sentences that do not adequately describe the preceding picture. A review of research reports over the last decade shows that it is challenging to conclude that P600 reflects only (morpho-)syntactic processing load.

This study reports the results of an experiment examining how the occurrence of the P600 effect is affected by processing loads created by syntactically complex sentences and the context formed by line drawings. Through this experiment, we describe changes observed in the appearance of P600 depending on the experimental conditions and provide facts to discuss the P600’s functional significance.

2 Word order and sentence-processing cost: Previous studies

Previous research in psycholinguistics and cognitive neuroscience show that derived word orders tend to be relatively higher in processing cost than the syntactic basic word order of each language (for Japanese: Mazuka, Itoh, and Kondo 2002; Miyamoto and Takahashi 2002; Ueno and Kluender 2003; Koizumi and Tamaoka 2004; Tamaoka et al. 2005). Scholars propose that the reason for the higher processing cost of derived word orders is that the syntactic structure of derived word order is more complex than that of basic word order (Marantz 2005), and additional information processing such as filler-gap dependency processing is required (Gibson 2000; Hawkins 2004). Regardless of what model is assumed, we can predict that the processing cost of derived word-order sentences will be larger than that of basic word-order sentences. It suggests that measuring the size of the processing load can provide clues as to the basic word order of a language.

Before reporting the experiments regarding this study, we introduce two related studies that explored the relationship between free word-order phenomena and sentence-processing load in Kaqchikel. Kaqchikel is the Mayan language spoken in Guatemala (Tay Coyoy 1996; Brown, Maxwell, and Little 2006; Lewis 2009). This language allows for free alternation of the subject (S), object (O), and verb (V) word orders. In the case of transitive sentences, all six logically possible word orders are grammatical, including (1b) VSO and (1c) SVO, in addition to the VOS in (1a). Among these word orders, the VOS has been historically and theoretically considered the canonical word order (Rodríguez Guaján 1994; Tichoc Cumes et al. 2000; Ajsivinac Sian et al. 2004; England 1991; Aissen 1992).

(1)	a.	VOS order	X-*ϕ*-*u*-chöy	ri chäj	ri ajanel.
			PAST-3sgABS.-3sgERG cut	DET pine tree	DET carpenter
	b.	VSO order	X-*ϕ*-*u*-chöy	ri ajanel	ri chäj.
	c.	SVO order	Ri ajanel	X-*ϕ*-*u*-chöy	ri chäj.
			"The carpenter cut the pine tree."		

In a language that allows for such free alternation of word order, the answer to the question "What is the basic syntactic order of the language?" is often debated. The two studies presented here are cognitive neuroscience studies that examine the basic word order in Kaqchikel. Yasunaga et al. (2015) and Yano, Yasunaga, and Koizumi (2017) addressed a common question: "If VOS is the canonical word order, do the other word orders, as derived word orders, increase the processing load?" Despite this commonality, the two studies employ slightly different experimental methods.

Yasunaga et al. (2015) used a picture-sentence (PS) matching task where participants were asked to judge whether the content of the preceding picture matched that of the following sentence. Their findings are as follows: When comparing the second region of the VOS and VSO word orders, P600 was observed for VSO. They noted that even in modern Kaqchikel, the basic word order in the mind of the native speaker is VOS, and the other word orders are processed as derived word orders. Furthermore, Yasunaga et al. (2015) identified several problems in this study. As the relative order of presentation was "picture, then sentence," perhaps the sentence structure was already created in the participants' minds by the time they saw the picture, and the EEG picked up inconsistencies in the matching process between the "sentence structure created first" and the "sentence actually heard." That is, the P600 reported by Yasunaga et al. (2015) did not reflect the load of processing a sentence with a complex structure; however, it could have reflected the load caused by processing a sentence different from the one constructed by the context (line drawing).

Yano, Yasunaga, and Koizumi (2017) adopted a sentence-picture (SP) matching task in which the order of stimulus presentation was the reverse of that used by Yasunaga et al. (2015) to overcome the problems they identified. First, the sentence was presented, and then the participants were asked to judge whether it matched the content of the picture that followed. EEG measurements were taken while participants listened to the sentence; thus, the brain response was only recorded before looking at the picture. The findings are as follows: When comparing the third region of the VOS and VSO word orders, P600 was observed for the VSO word order. The authors noted that the filler-gap dependency could be processed in the second region because the context was given in Yasunaga et al.'s (2015) experiment. However, in Yano, Yasunaga, and Koizumi's (2017) experiment, the context was not given—thus, the processing of the filler-gap dependency does not occur until the third region. The difference in gap-filling processing of the filler-gap dependency yielded a difference in the timing at which P600 was observed.

Yasunaga et al. (2015) and Yano, Yasunaga, and Koizumi (2017) reported that P600 was observed for the derived word order in Kaqchikel. Two additional questions, thus, arise. The first regards whether scrambled Japanese sentences also produce the P600 effect in the PS and SP tasks. Several prior studies report that P600 is observed in scrambled Japanese sentences, but whether it is observed in SP or PS tasks has yet to be reported. Second, performing the two tasks on the same participant allows for considering whether there is any new suggestion to determine the functional significance of P600. Thus, we performed SP and PS tasks on the same participants using Japanese scrambled sentences.

3 Experiments

The experiment reported in this section was conducted during the COVID-19 pandemic, which induced various limitations, such as the small number of participants.

In the experiment, data for the SP and PS tasks were obtained from each participant. The order of the SP and PS tasks was counterbalanced by the participants. Participants comprised 16 native Japanese speakers from Kanazawa University (10 men and six women; M=21.2 years old, range 18–22 years). All participants were right-handed and had normal vision and hearing. Informed consent was obtained before participation, both verbally and in writing. The study was approved by the ethics committee of Kanazawa University. The experiment was conducted per the guidelines for face-to-face research under COVID-19 conditions set by Kanazawa University.

3.1 Stimulus

The pictures used as stimuli in the experiment were the same as those used by Yano, Yasunaga, and Koizumi (2017), as shown in Figure 1. Six transitive actions that could be expressed using simple line drawings were adopted. Agents and patients were distinguished by four colors: blue, red, black, and white. The number of pictures in which the agents appeared on the left and right sides was balanced.

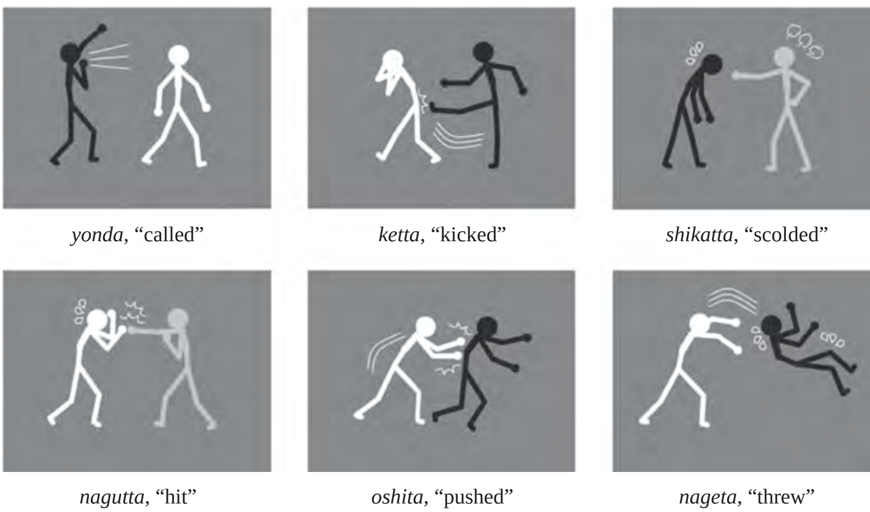

Figure 1: Examples of the pictures used as stimuli.

Two types of sentences were also prepared, as shown in (2). The first was SOV word-order sentences (referred to as SO order), in which the subject precedes the object (usually considered the canonical word order in Japanese). The other type was OSV order sentences (referred to as OS order), in which the object precedes the subject (usually called scrambled sentences).

(2)	a.	SO order	aka-ga	ao-o	yon-da.
			red-NOM	blue-ACC	called
	b.	OS order	ao-o	aka-ga	jon-da
			"The red (person) called the blue (person)."		

We recorded the speech of a female speaker in the Tokyo dialect. The length of the audio stimuli was adjusted to minimize the variability in ERP response latency, as shown in Tables 1 and 2.

Table 1: Speech duration of each speech stimulus in the first and second regions (unit: ms).

	NP-*ga* in SO	NP-*o* in SO	NP-*ga* in OS	NP-*o* in OS
aka, “red”	407	404	403	406
ao, “blue”	400	400	403	409
kuro, “black”	404	402	404	403
shiro, “white”	410	408	411	405
AVG.	405	404	405	406
SD.	3.70	2.96	3.34	2.17

Note: NP: noun phrase

Table 2: Speech duration of each speech stimulus in the third region (unit: ms).

	SO order	OS order
nagutta, “hit”	471	472
ketta, “kicked”	398	399
oshita, “pushed”	416	414
jonda, “called”	412	412
shikatta, “scolded”	471	471
nageta, “threw”	396	396
AVG.	427	427
SD.	31.7	31.9

The stimulus onset asynchrony was set to 1,200 ms to avoid overlapping responses with the previous region. All speech materials were checked for unnatural pronunciation and inaudibility by three native Japanese speakers who did not participate in the ERP experiment.

3.2 Procedures

The SP task was conducted per the following procedure: First, a numbered countdown, followed by the white cross for the fixation, was displayed. When the cross turned red (depicted in black in Figure 2), the audio clip of the experimental sentence was played. After the sentence was presented, a picture was shown, and the participants had to press a button to respond regarding whether the sentence and picture matched. The EEG was recorded while the red cross was displayed. The entire task comprised 48 YES trials in the SO order, 48 trials in the OS order, and 96 NO trials, all presented to the participants in random order. The task was divided into six blocks with rest periods. The Psychtoolbox 3.0.17 (Brainard 1997;

Pelli 1997; Kleiner, Brainard, and Pelli 2007), which runs on MATLAB R2020a (The Mathworks, Inc.), was used to present the stimuli and acquire the participants' behavioral responses.

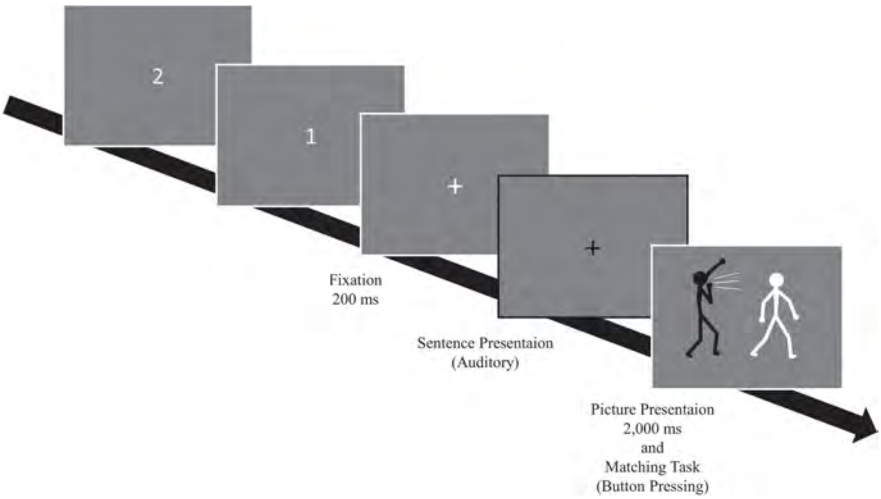

Figure 2: Procedure of the sentence-picture matching task.

However, in the PS task, the picture was presented before the sentence. A countdown was followed by a picture that was displayed for 2,000 ms. A fixation cross was then displayed, and the sentence audio clip was presented. Subsequently, a question mark was displayed. The participant then answered whether the picture and the sentence conveyed the same meaning by pressing a button. This task comprised 48 YES trials in the SO order, 48 trials in the OS order, and 96 NO trials. In the NO trial, for example, a picture of "a black person kicking a white person" was presented, as shown in Figure 3, but the audio clip "*aka-ga ao-o nagutta.* (The red hit the blue)" was played. Moreover, there were so-called "role reversal sentences" (sentences in which thematic roles are reversed). There were 48 trials in which the color of the actor or patient differed between the sentence and the picture, 24 trials in which the thematic roles were reversed, and 24 trials in which the verb content differed between the sentence and the picture. This task was divided into six blocks with rest periods.

The EEG was recorded from 19 locations on the participant's scalp using the amplifier Polymate AP1532. Nineteen tin electrodes were used with an elastic cap. The linked earlobe served as the reference. The sampling rate was set to 1,000 Hz, and the bandpass filter was set to 0.01–100 Hz.

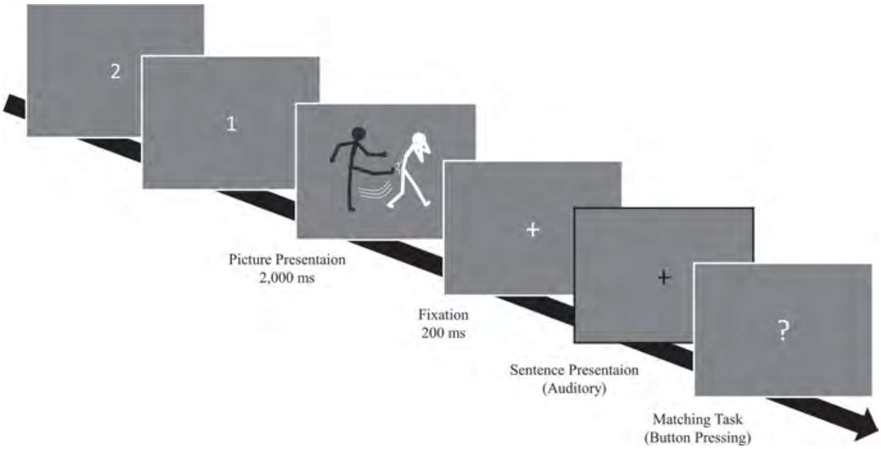

Figure 3: Procedure of the PS task.

The EEG data were analyzed using EEGLAB v2020.0 (Delorme and Makeig 2004), running on MATLAB R2020a. Before averaging, the EEG data were downsampled to 200 Hz and re-filtered to 0.05–50 Hz. The ERP was quantified by averaging in the –200~1,000 ms time window (–200~0 ms was the baseline). Trials with ERP artifacts exceeding ±80 μV in these time windows were automatically eliminated. For exploratory analysis, the amplitudes were separated every 100 ms. The error trials that responded NO in the match condition or YES in the mismatch condition were also excluded in averaging.

4 Results and discussion

4.1 Behavioral data

In both tasks, no difference in the percentage of correct responses to the matching task was observed regarding the word order (SP task: SO 96.3% ≒ OS 95.2%; PS task: SO 98.2% = OS 98.2%).

In the SP task, the reaction time was significantly shorter in the SO order than in the OS order ($t(15) = 3.36$, $p < 0.05$). However, in the PS task, the reaction time was numerically longer in the OS order than in the SO order, although the difference was not statistically significant ($t(15) = 1.17$, *n.s.*). Perhaps the difference in reaction time between the SO and OS orders did not reach significance in the PS task because the pictures provided sufficient contextual information. Some studies show that constructions considered to lead to large processing costs in nature can be reduced by appropriate context. For example, Koizumi and Imamura (2017) show that the OS order in which the object is the old information demanded a smaller processing load than the OS order in which the object is the new information. Yano and Koizumi (2021) show that given the appropriate context, the processing difficulty of OS order becomes smaller than that of SO order. In the PS (SP) task, the participants pressed the button after hearing (seeing) the sentence (picture). Thus, we could not directly compare the reaction times across tasks because the participants made decisions at different times.

Table 3: Correct response rate and reaction time for the two tasks.

	Correctness	Reaction Times
SO order in PS task	98.2 (1.82)	341 (193)
OS order in PS task	98.2 (2.88)	351 (212)
SO order in SP task	96.3 (4.30)	903 (355)
OS order in SP task	95.2 (6.27)	960 (409)

(units; % of correctness, ms in reaction time)
Note: Numbers in parentheses are standard deviations.

Summarizing the data for the behavioral indicators, the overall trend suggested that the OS order was more challenging than the SO order. This trend is consistent with several studies on Japanese scrambled sentence processing.

4.2 Event-related brain potentials data

First, we report ERP data for the SP task. In this task, the effect of word order on amplitude was observed only in the second region. In the 500–600 ms time window, the ERP for the OS order significantly and positively shifted relative to the ERP for the SO order ($p < 0.05$).

However, in the PS task, the effect of word order on amplitude was observed in all regions. In all regions, the OS order was shifted in a positive direction relative to the SO order (R1: $p < 0.05$; R2: $p < 0.01$; R3: $p < 0.001$). Figures 5a, 5b, and 5c show all waveforms and topographies.

In summary, the effect of word order was observed only in the second region of the SP task. In the PS task, this was observed in all the regions. In the following sections, we discuss the results for each region across the two tasks.

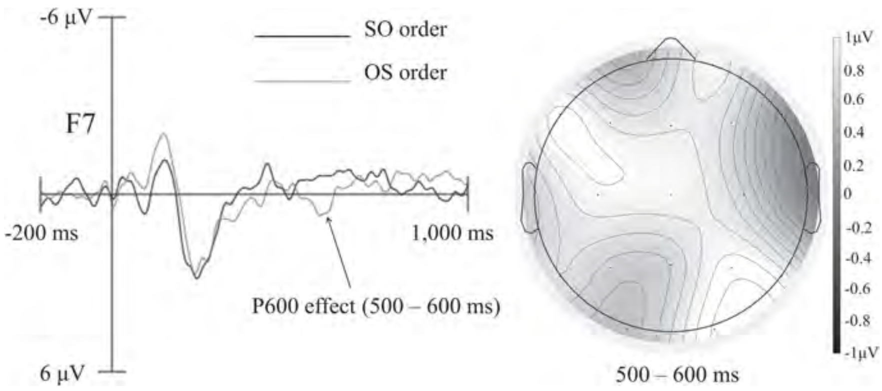

Figure 4: Event-related brain potential waveform and potential map in the second region of the SP task. The potential map shows the difference of OS order minus SO order in the 500–600 ms time window.

4.3 Discussion

P600 observed in the first region of the PS task: In the first region, P600 was observed only in the PS task and not the SP task. Regarding the PS task, a participant can anticipate what type of sentence will be an input based on the picture presented before the sentence, as noted by Yasunaga et al. (2015). This result can be interpreted as a "surprise" caused by the input of an element different from the participant's expectation, reflected as P600. Previous studies reported negative components for the first region in OS order (i.e., the object at the beginning of the sentence), reflecting working memory load and deviation from predictions regarding dependency construction (Hagiwara et al. 2007; Ueno and Kluender 2003). However, in this study, this negative effect was rarely observed in this domain, and P600 was observed instead. The author interprets this P600 as a component that reflects a more general cognitive load, independent of deviations from syntactic predictions. In the SP task, P600 was not observed in the first domain. Thus, the difference between the two tasks may stem from the presence (absence) of P600. Vissers et al. (2008) also report that P600 was observed in the PS task when a sentence was presented that did not match the content of the preceding picture. The P600 has a 500–700 ms latency and was observed in the whole scalp, mainly in Cz. P600, which was observed in the first region of this study, in the same time window, and with similar scalp distribution. Therefore, the P600 observed in the first region of the PS task reflects the same cognitive process as that noted by Vissers et al. (2008).

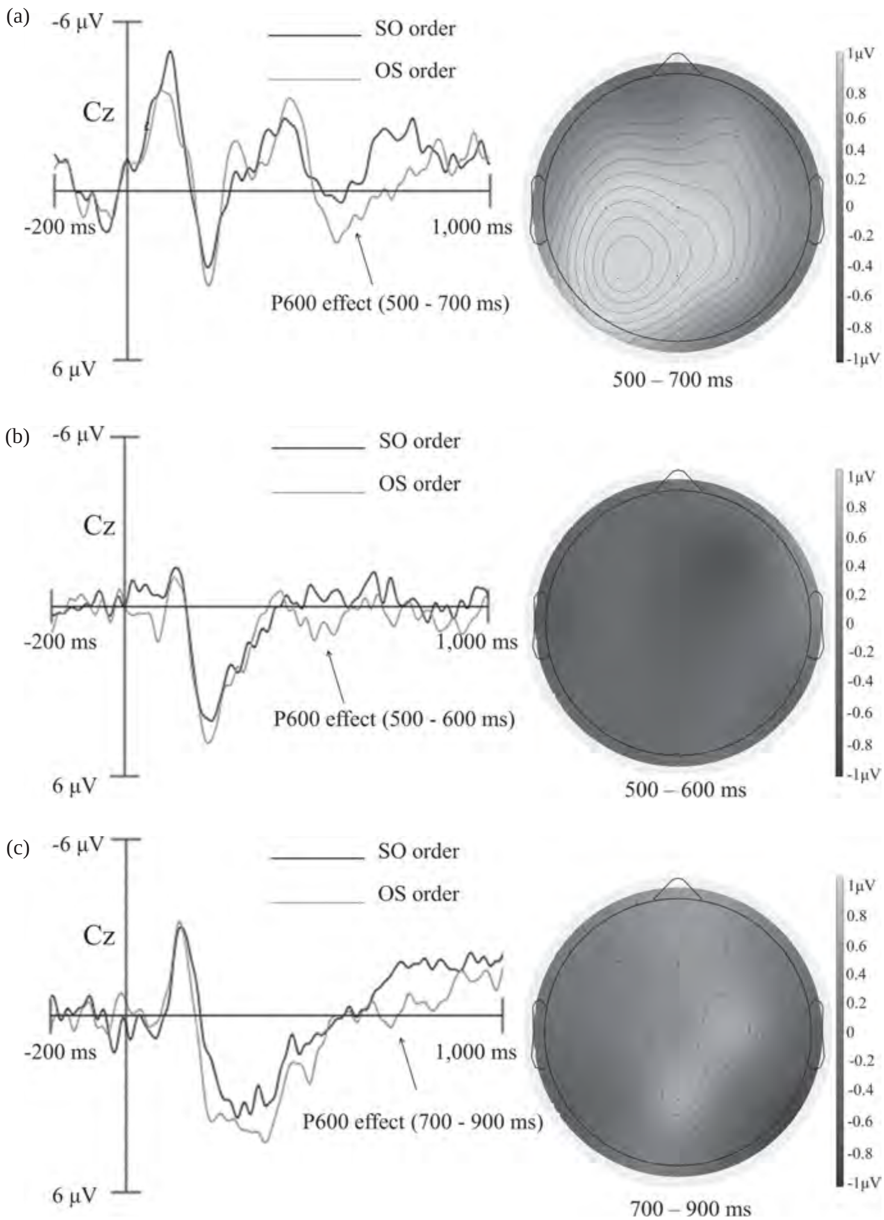

Figure 5: Event-related brain potential waveforms and potential maps of the picture-sentence matching task: (a) the first region, (b) the second region, and (c) the third region. The potential map shows the difference of OS order minus SO order. The time window of each map is shown under the map.

However, as no context was given in the SP task, P600 was not observed because no "surprise" occurred, unlike in the PS task. These interpretations suggest that P600 is unlikely to be an ERP component specific to syntactic processing. If P600 is an ERP component specific to syntactic processing, the same degree of effect should be observed for the derived word order in the first region, regardless of the task.

P600 observed in the second region of the SP and PS tasks: In the second region, P600 was observed in the SP and PS tasks. In the SP task, sentence processing takes place without the context (picture) being given; thus, the brain's response is likely to reflect sentence processing more purely. The P600 in the second region of scrambled Japanese sentences accords with the results of previous studies, such as Hagiwara et al. (2007), Ueno and Kluender (2003), and Yano and Koizumi (2018). Thus, this component, as observed in this study, may stem from the processing load of the filler-gap dependency associated with the processing of scrambled sentences.

However, if P600 reflects only the syntactic processing load, the PS task should yield results similar to the SP task. Although the amplitude difference of the second P600s between the PS and SP has not yet reached statistical significance (n = 16, p = 0.07), different scalp distributions of their amplitude effects are observed by visual inspection. The second P600 in the SP is widely distributed, suggesting that this P600 possesses neural generators in deeper brain regions. However, the corresponding effect in the PS focally appears in the frontal regions. Thus, the second P600 in the PS may be generated from surface, localized cortical regions. If we accept the distributional difference in the second P600s between the two tasks, beyond processing filler-gap dependency in the second region, a more general cognitive load was superimposed in the PS task.[7]

If we accept the difference in P600 amplitude between the tasks in the second region, beyond processing filler-gap dependency, a more general cognitive load, as observed in the first region, was superimposed in the PS task.

P600 observed in the third region of the PS task: In the third region, the P600 was observed in only the PS task but not the SP task. In this region, there was no betrayal of participants' predictions for verbs, as verbs always appear in this region. Moreover, we analyzed only cases where the picture and sentence matched. Unexpectedly, the filler-gap dependency will be processed in this region. Therefore, we must consider that the P600 in the third region reflects a cognitive process different from the first and second regions.

7 The discussion in this paragraph was built on comments from anonymous reviewer #2. Further clarification of the three relationships between the source of P600, its distribution on the scalp, and the functional significance of P600 will clarify the implications of the various P600s observed in this study.

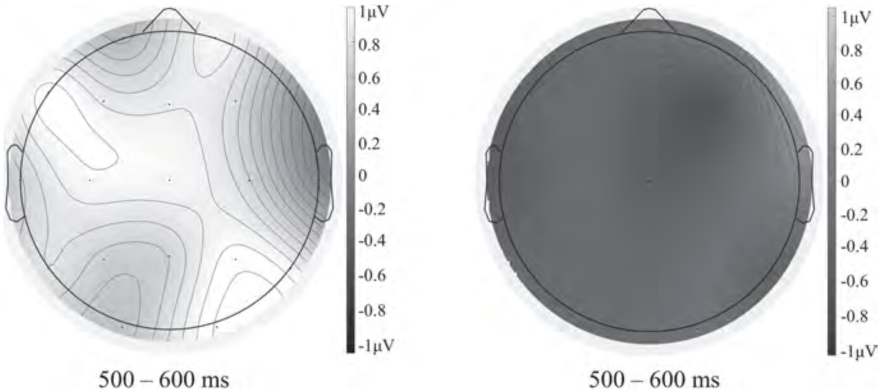

Figure 6: Comparison of the strengths of the effects of the second region in the sentence-picture matching task (left panel) and in the picture-sentence matching task (right panel).

In the PS task, the participants were required to make a final decision regarding whether the picture and sentence matched after the input of the third region. Participants reviewed the entire sentence again for the matching task. This task reconfirmed the mismatches in the first and second regions; thus, the processing load increased again. One piece of supporting evidence for this possibility is that the time window for P600 in the third region was relatively late. This somewhat late response was likely because the task required a process of synthesizing the context (picture) and the whole sentence.

5 Summary

This study addressed two questions. First, would scrambled Japanese sentences also produce a P600 effect during the SP and PS tasks? The answer is yes. P600 was observed in the region where the filler-gap dependency could be processed (the second region). Second, would we find any new insights regarding P600 by performing the two tasks on the same participants? In the PS task, where contextual information was available, P600 was also observed per the mismatch between the context and expectation and the participant's final decision on the task. These facts suggest that P600 is not just a reflection of syntactic challenges, and superimposed P600 may also be observed with a broader range of cognitive loads (specifically, failure of expectations).

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Masataka Yano

Chapter 7
The adaptive nature of language comprehension

1 Introduction

Human language-processing studies have generally focused on the fixed aspects of processing mechanisms, with an (often implicit) assumption that they do not vary over time (Bornkessel and Schlesewsky, 2006; Frazier, 1987; Friederici, 2002; Hale, 2001; Lewis, Vasishth, and Van Dyke, 2006; MacDonald, Pearlmutter, and Seidenberg, 1994). However, speakers vary in terms of their lexical and syntactic knowledge and preferences (Bloom and Fischler, 1980; Han, Musolino, and Lidz, 2016; Sprouse, Wagers, and Phillips, 2014). Given that language processing is highly predictive, such variation induces the language-processing system to encounter prediction errors (Altmann and Kamide, 1999; Federmeier, 2007; Kamide, Altmann, and Haywood, 2003; Luke and Christianson, 2016). Thus, this brings up a question about how the language-processing system deals with repeated exposure to unexpected input in sentence comprehension.

Recent behavioral studies show that comprehenders can rapidly adapt to linguistic characteristics of input (Creel, Aslin, and Tanenhaus, 2008; Farmer et al. 2014; Fine and Jaeger, 2013, 2016; Fine et al. 2013; Kaan and Chun, 2018b; Kamide, 2012; Kurumada, Brown, and Bibyk, 2014).[1] For instance, while people experience difficulty in the processing of garden-path sentences that require a revision of syntactic structures (e.g., “The experienced soldiers warned about the danger conducted the midnight raid”), Fine et al. (2013) found that the difficulty of processing garden-path sentences decreased as participants were repeatedly exposed to them in an experiment. Sharer and Thothathiri (2020) revealed that this syntactic adaptation effect was correlated with activation in the pars opercularis of the left frontal cortex. Importantly, adaptation differs from syntactic priming in that it is cumulative (i.e., a gradual convergence toward the statistics of the input) and long-lasting (Kroczek and Gunter 2017). However, the underlying mechanism

1 For this chapter, we used the term “adaptation” to refer to when language processing changes in a relatively short period, resulting in a more suitable state for an environment.

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has not been fully understood. Further, as the previous experiments are limited regarding target languages (i.e., English and German) and constructions (i.e., structural ambiguity resolution and alternation), the limit of the adaptive behavior is unknown.

1.1 Underlying mechanisms

Previous accounts can be broadly categorized into two positions. The expectation-updating account proposes that the language-processing system has a probabilistic belief about how often certain types of sentences appear. When encountering a less frequent and, thus, unexpected structure, the belief is updated accordingly (Fine et al. 2013; Fine and Jaeger 2013). Consequently, the same structure is processed more easily. The alternative interpretation, in contrast, the alternative interpretation assumes that various syntactic frames are stored with different base-level activation in declarative memory. When a less frequent syntactic frame is repeatedly used, its base-level activation increases; hence, its activation subsequently requires a lower cost to exceed the activation threshold (Reitter, Keller, and Moore 2011; cf. Kaan and Chun 2018b). Therefore, the processing of *a priori* infrequent syntactic frames is facilitated. We refer to this account as a representation-based account. As prior behavioral studies of adaptation have mainly focused on the processing of structural ambiguity resolution, it is difficult to tease these two accounts apart.

For this chapter (Experiments 1 and 2), we tested the two accounts in two ways. Experiment 1 involved morphosyntactically ungrammatical sentences. If people can adapt to ungrammatical sentences, it would imply going against the representation-based account because, by definition, such sentences do not have any licit syntactic frame; thus, the activation level cannot increase. To date, it remains unclear whether ungrammatical sentences trigger adaptation (Coulson, King, and Kutas, 1998; Gunter and Friederici, 1999; Hahne and Friederici, 1999; Osterhout et al. 1996; Yoshida and Miyamoto, 2017).

For Experiment 2, we tested whether the strength of predictive errors influences adaptation using aspectual mismatches. The expectation-updating account predicts that a stronger prediction error will trigger updating an expectation about linguistic environments, because it signals that the belief substantially deviates from what should be expected. The representation-based account, on the other hand, does not predict such an outcome because the aspectual representation is the same, regardless of predictive strength.

1.2 Limits of linguistic adaptation

Another issue addressed in this study involves the limits of adaptation. It is plausible to suppose that the language-processing system is well designed to adjust to a linguistic environment to process input efficiently. However, adaptation is presumably not limitless because continuously tracking changes in linguistic environments could be demanding of resources.

Several prior findings suggest that different types of prediction errors have different effects on adaptation. For example, Hanulíková et al. (2012) observed that native speakers of Dutch exhibit no P600 effect for sentences with gender disagreement produced by a non-native speaker. In contrast, semantic violations elicited an N400 effect, suggesting that people are less likely to adapt to semantic violations (Grey and Hell, 2017; Romero-Rivas, Martin, and Costa, 2015, 2016). Thus, for Experiment 3, we tested whether repeated exposure to semantic violations mitigated processing difficulties in Japanese individuals.

For this chapter, we used event-related potentials (ERPs) because they allowed for selectively tracking how processes of interest changed during the experiments. Further, by using ERPs as an index of sentence processing costs, we could avoid the possibility that apparent adaptation effects would result from response familiarization involved in sentence plausibility judgment and self-paced reading tasks.

2 Experiment 1: Morphosyntactic adaptation

2.1 Method

For Experiment 1, we tested the expectation-updating and representation-based accounts using morphosyntactic violations, as shown in (1b). The sentence in (1a) is grammatical, while that in (1b) entails a morphosyntactic violation, as an intransitive verb must mark a single argument with a nominative case (“-ga”), but not with an accusative case (“-o”), regardless of the agentivity of the argument in Japanese. We divided 52 pairs of the target sentences, such as (1), into two lists according to the Latin square design, such that each participant read 26 sentences of each condition.

(1) a. Grammatical sentence:
bara-ga kare-ta.
rose-NOM wither-PST
“The rose withered.”

b. Morphosyntactic violation:
*bara-o kare-ta.
rose-ACC wither-PST

The morphosyntactic violation has been reported to elicit a P600 effect compared to the grammatical counterpart in Japanese and in other languages (Nashiwa, Nakao, and Miyatani, 2007; Yano, 2018b; Yano and Sakamoto, 2016b). Thus, a decrease in the P600 effect over the course of the experiment can be interpreted as an adaptation to morphosyntactic violations. However, the magnitude of the P600 effect could have changed during the experiment for several reasons other than adaptation, such as participants' fatigue and lack of attention. To assess these effects, we manipulated the probability of grammatical and ungrammatical sentences and examined whether ERP differences between ungrammatical and grammatical sentences decreased only when the participants were exposed to a large proportion of ungrammatical sentences. We manipulated the ratio of the grammatical and ungrammatical sentences by intermixing filler sentences. In the equal-probability block, the ratio of grammatical and anomalous sentences was 1 to 1, while the ratio was 4 to 1 in the low probability block. We informed the participants that they would complete two blocks but not how they differed (i.e., the manipulation of probability is a within-participant factor).

We recruited 20 native Japanese speakers from Tohoku and Kyushu University. All participants (including those who participated in Experiments 2 and 3) had normal or corrected-to-normal vision and no history of reading disabilities or neurological disorders. We obtained written informed consent from all participants before the experiments. The experiments were approved by the ethics committees of Tohoku University's Graduate School of Arts and Letters and Kyushu University's Department of Linguistics.

Sentences were presented word-by-word. We conducted statistical analyses using linear mixed-effects (LME) models, which allowed for handling continuous variables, including ITEM ORDER. The models included independent variables of interest: PROBABILITY (low/equal), VIOLATION (grammatical/ungrammatical), and ITEM ORDER of each block (1–130), with their interactions as fixed factors. The dependent variables were 700–900 ms mean amplitudes from the onset of the verbs (i.e., "withered"), calculated for each trial. The time window was determined based on the results of previous ERP studies in Japanese, which showed relatively late P600 effects (Mueller, Hirotani, and Friederici, 2007; Nashiwa et al. 2007; Yano, 2018b; Yano and Sakamoto, 2016b; Yano, Suzuki, and Koizumi, 2018). As the topographical distribution of P600 is well known, we used EEG data obtained from the centroparietal regions (Cz, Pz, C3/4, P3/4, P7/8, and O1/2).

The focus of this experiment was whether the magnitude of the P600 effect would change over the course of each block, depending on the probability of anomalous sentences. The representation-based account predicts that participants cannot adapt to morphosyntactic violations because ungrammatical sentences have no licit representation to be activated. Thus, the P600 effect should appear throughout both low- and equal-probability blocks. Alternatively, if the P600 effect were to change due to reasons other than adaptation, we expected the interaction of VIOLATION × ITEM ORDER in both blocks, in addition to the main effect of VIOLATION. In contrast, the expectation-updating account predicts that participants can adapt to morphosyntactic violations with increasing exposure to them (though not necessarily). Statistically, it should induce a significant interaction of PROBABILITY × VIOLATION × ITEM ORDER, reflecting an attenuation of the P600 effect during the equal-probability block.

2.2 Results

The LME model showed a significant main effect of VIOLATION, with the ungrammatical sentences having larger P600 amplitudes ($\hat{\beta}$ = 2.38, t = 2.70, p < 0.05) (Figure 1). Importantly, the three-way interaction reached a significant level ($\hat{\beta}$ = −2.85, t = −7.27, p < 0.01). Planned comparison at each level of PROBABILITY showed

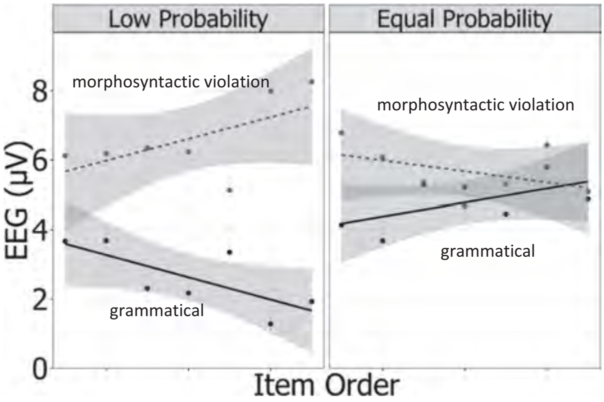

Figure 1: The P600 change in the low (left) and equal (right) probability blocks of Experiment 1. The x-axis denotes item order, and the y-axis denotes the amplitude of the P600 in the time window of 700–900 ms. Positivity is plotted upwards. Each line shows the P600 changes estimated by the LME models, and each dot indicates a P600 amplitude for every 20 trials. The gray areas refer to the 95% confidence interval.

that ITEM ORDER had a different effect on the P600 effect for the two blocks. In the equal-probability block, the interaction of VIOLATION and ITEM ORDER was significant, with a decrease in the magnitude of the P600 effect ($\hat{\beta} = -1.57$, $t = -5.72$, $p < 0.01$). In contrast, the P600 effect increased during the low probability block ($\hat{\beta} = 1.27$, $t = 4.56$, $p < 0.01$).

2.3 Discussion

The results of the equal-probability block demonstrated that the language-processing system can adapt to morphosyntactically violated sentences. The decreased magnitude of the P600 effect stemmed from the ungrammatical sentences eliciting a smaller P600 amplitude as the experiment progressed. Thus, the outcomes corroborated the prediction by the expectation-updating account. Although the exact functional contribution of P600 to language comprehension remains debated (Bornkessel-Schlesewsky and Schlesewsky, 2008; Brouwer, Fitz, and Hoeks, 2012; Kaan and Swaab, 2003a, 2003b; Kolk et al. 2003; Kuperberg, 2007; Van Herten, Kolk, and Chwilla, 2005). Fitz and Chang (2019) recently proposed that a P600 reflects the cost of a learning process to develop an accurate probabilistic model. According to their computational model, when the language-processing system faces a processing error, it propagates the error back to the lower-level units to enable learning of probable input. If their interpretation of P600 is correct, the P600 reduction reflects a successful learning process that minimizes the processing error.

Moreover, the observation that the opposite pattern was found for the low probability block supports the expectation-updating account. In the low probability block, the P600 amplitude decreased for grammatical sentences and increased for ungrammatical sentences. As the preverbal phrase provided useful information on the syntactic structure of a sentence in this block, the participants incorporated this information into their predictive computations. Consequently, processing was facilitated for the verb, attenuating the P600 amplitude of grammatical sentences. On the other hand, such an expectation should induce a severe processing cost for the verbs of ungrammatical sentences. Thus, the participants needed to repair the syntactic structure of the sentence upon encountering the verb. The rise in the P600 amplitude observed for the ungrammatical sentences can be considered a consequence of such processing errors, since the participants expected a grammatical sentence more strongly as the experiment went along.

In contrast, the present outcome is not compatible with the hypothesis that accounts for syntactic adaptation in terms of syntactic representation activation. According to this interpretation, increased base-level activation or the residual activation of syntactic frames facilitates the processing of subsequent sentences with the same syntactic frames. Because ungrammatical sentences (e.g., case-assignment violations) do not have a licit syntactic representation that Japanese speakers can build upon, it is impossible to increase the activation level of such syntactic representations. One may consider an alternative possibility that the participants built an improvised representation of the ungrammatical target sentences as they encountered them (cf. Kaschak and Glenberg 2004). However, this account is unlikely to explain the results because we kept the number of ungrammatical target sentences constant between the low- and equal-probability blocks; therefore, the repeated presentation of case-assignment violations should have facilitated their processing in the low- and equal-probability blocks to the same degree. We only observed the decline in the magnitude of the P600 effect for the equal-probability block, which is at odds with the representation-based account.[2]

Thus, we interpreted the results as evidence suggesting that expectation-updating is an underlying mechanism for (morphosyntactic) adaptation.

3 Experiment 2: Aspectual adaptation

For Experiment 2, we tested the two accounts from different angles. A strong expectation violation signals to the language-processing system that the current prediction model is incorrect. Hence, if the expectation-updating account is on the right track, the language-processing system should attempt to update its expectation (Fine and Jaeger 2013). In contrast, the representation-based account does not make such a prediction as long as the representations in question do not differ. To test this prediction, we employed aspectual coercion, which refers to when an aspectual type is forced to shift to another type to reconcile an aspectual mismatch between temporal adverbials and verbs, for instance (e.g., Jackendoff, 1997; Moens, 1987; Moens and Steedman, 1988). For example, the originally semelfactive event of "*sneeze*" in "*For 10 minutes, the student sneezed*" is an iterative event given the co-occurrence with "*for 10 minutes*."

Aspectual coercion induces additional processing costs compared to non-coerced sentences (Bott, 2010; Long, 2011; Paczynski, Jackendoff, and Kuperberg, 2014; Yano and Sakamoto, 2016a). Yano (2018b) found that processing costs reflect two types of processes: an aspectual prediction error reflected by an ERP component called early anterior negativity (AN) and an aspectual mismatch resolution process

2 The representation-based account cannot also account for the P600 *increase* in the grammatical sentences of the equal probability block because it should expect the opposite pattern such that the P600 amplitude decrease as the participants read more sentences, reflecting increased activation.

reflected by a later AN. For Experiment 2, we focused on the early AN because we were interested in whether predictive processing plays a role in adaptation.

3.1 Method

We used two types of aspectual coercion: the additive and subtractive types, as exemplified in (2) and (3). The additive type refers to an aspectual shift from an atelic to a telic interpretation, as shown in (2b). In the subtractive type, a telic interpretation turns into an atelic interpretation given a for-adverbial phrase, as presented in (3b). We assessed the additive and subtractive coercion effects against each control condition—portrayed in (2a) and (3a), respectively—which involves no aspectual shift. In addition to these two factors (coercion and type), we manipulated the temporal distance between the adverb and the verb, such that the adverb was placed at the sentence-initial position in Experiment 2A, while it was adjacent to the verb in Experiment 2B. Assuming that linguistic prediction develops as a function of time (even when available information does not change), a stronger prediction error should have occurred in the coercion conditions of Experiment 2A (Chow et al. 2018; Yano 2018a, 2018b).

(2) a. Control:

(30-pun-kan)	kooti-ga	sensyu-o	(30-pun-kan)
30-minute-for	coach-NOM	player-ACC	30-minute-for

sidoo-si-ta.
instruct-do-PST
"The coach instructed the player for 30 minutes."

b. Additive type:

(30-pun-de)	kooti-ga	sensyu-o	(30-pun-de)
30-minute-in	coach-NOM	player-ACC	30-minute-in

sidoo-si-ta.
instruct-do-PST
"The coach instructed the player in 30 minutes."

(3) a. Control:

(30-pun-de)	sinnyuu-syain-ga	syorui-o	(30-pun-de)
30-minute-in	new.employee-NOM	paper-ACC	30-minute-in

insatu-si-ta.
print-do-PST
"The new employee printed the papers in 30 minutes."

b. Subtractive type:

(30-pun-kan)	sinnyuu-syain-ga	syorui-o	(30-pun-kan)
30-minute-for	new.employee-NOM	paper-ACC	30-minute-for
insatu-si-ta.			
print-do-PST			

"The new employee printed the papers for 30 minutes."

Following the Latin square design, we presented 30 sentences of each condition to the participants. We added 60 implausible sentences as fillers (e.g., "The actress found a wallet for 20 minutes") to create correct NO responses to the acceptability judgment task performed at the end of each trial. Unlike Experiment 1, for Experiment 2, we did not manipulate the ratio of sentences, as we could examine the adaptation effect by comparing the results of the two experiments.

We recruited 32 native speakers of Japanese from Kyushu University and randomly assigned them to either of the two experiments. The experiments and EEG analyses followed that of Experiment 1. In Experiment 2, the dependent variables were mean amplitudes of a 300–500 ms time window from the onset of the verbs (i.e., "instructed/printed"). Based on previous observations (Yano 2018b; Yano and Sakamoto 2016b), we included EEG data obtained from the anterior regions (Fz, F3/4, and F7/8). The fixed factors were COERCION (control/coercion), COERCION TYPE (additive/subtractive), and ITEM ORDER, with their interactions.

This experiment focused on whether the magnitude of the early AN effect changed depending on the predictive power. If predictive processing were to play a role in adaptation, we expected that the early AN effect would only decrease in Experiment 2A or more strikingly in Experiment 2A than in Experiment 2B. This effect should have surfaced as a significant interaction of COERCION and ITEM ORDER, especially in Experiment 2A. In contrast, the representation-based account does not predict such a difference due to word order because both word orders end up having the same aspectual interpretation; thus, the repeated exposure of coercion should facilitate its processing to the same extent.

3.2 Results

The LME model showed a significant interaction of COERCION and ITEM ORDER ($\hat{\beta} = -0.04$, $t = -1.99$, $p < 0.05$) in addition to a marginally significant main effect of COERCION ($\hat{\beta} = -1.07$, $t = -1.82$, $p = 0.07$) in Experiment 2A (i.e. Adv-S-O-V order). The three-way interaction was not significant ($p > 0.10$). The results suggest that the early AN effect faded out in both coercion types toward the end of the experiment (Figure 2). However, Experiment 2B (i.e. S-O-Adv-V order) did not reveal a signif-

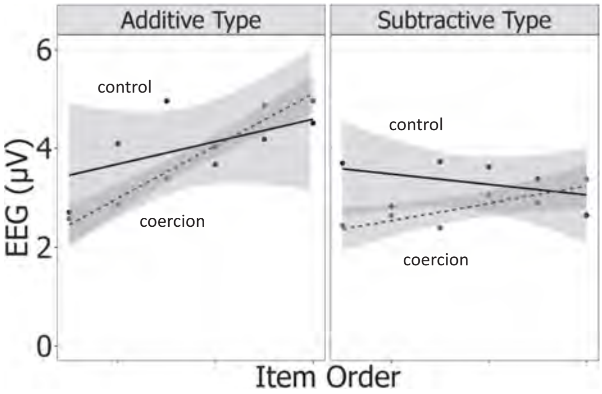

Figure 2: The early anterior negativity (AN) change in the additive (left) and subtractive (right) coercion in Experiment 2A.
The x-axis denotes item order, and the y-axis denotes the amplitude of the early AN in the 300–500 ms time window. Positivity is plotted upwards. Each line shows the early AN changes estimated by the LME models, and each dot indicates an estimated early AN amplitude for every 20 trials. The gray areas refer to the 95% CI.

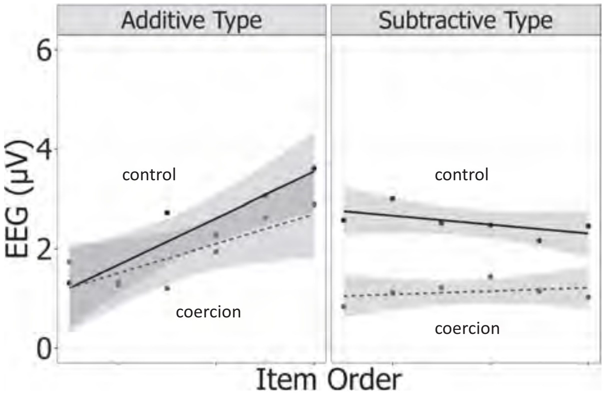

Figure 3: The early anterior negativity (AN) change in the additive (left) and subtractive (right) coercion in Experiment 2B.
The x-axis denotes item order, and the y-axis denotes the amplitude of the early AN in the 300–500 ms time window. Positivity is plotted upwards. Each line shows the early AN changes estimated by the LME models, and each dot indicates an early AN amplitude for every 20 trials. The gray areas refer to the 95% CI.

icant interaction of COERCION and ITEM ORDER ($\hat{\beta} = 0.00$, $t = -0.28$, $p > 0.10$) but showed a significant main effect of COERCION ($\hat{\beta} = -0.94$, $t = -2.21$, $p < 0.05$). Thus, the early AN effect persisted throughout the experiment (Figure 3).

3.3 Discussion

The results of Experiment 2A imply that the participants adapted to additive and subtractive types of aspectual coercion as the experiment progressed. It was not attributable to a simple familiarization with aspectual coercion or other factors that may have changed during the experiment because we noted a strikingly different pattern in Experiment 2B. The difference between the two experiments suggests that predictive processing plays a crucial role in adaptation. In line with the expectation-updating hypothesis, a stronger prediction error induced a greater adaptation effect (Jaeger and Snider 2013; Dell and Chang 2014; cf. Chang, Dell, and Bock 2006). Given that the participants had much time to predict the verbs, the aspectually mismatching verbs induced a stronger prediction error, triggering an expectation update. In contrast, the representation-based hypothesis does not provide a simple explanation for why Japanese speakers adapt to an aspectual mismatch only when the prediction was strongly disconfirmed.

4 Experiment 3: Semantic adaptation

Experiments 1 and 2 indicate that the language-processing system flexibly updates its expectation about upcoming input. This finding brings up a new question of how adaptive the language-processing system is. As we have seen thus far, adaptation to linguistic environments allows for efficient language processing. However, it arguably consumes processing resources, as it requires the language-processing system to track how probable sentences are in an ever-changing linguistic environment. Given this trade-off, linguistic adaptation may somewhat be limited. For example, the language-processing system may not adapt to semantic violations when it does not forecast processing benefits for the future.

For Experiment 3, we used semantic violations, which elicit an N400 effect, as well as semantically unexpected words (e.g., Kutas and Federmeier, 2000, 2011; Kutas and Hillyard, 1980, 1984; Lau et al. 2013, 2016; Nieuwland et al. 2020). Although the exact functional role of the N400 in sentence processing is a matter of debate, there is a consensus that it reflects lexico-semantic processing. Thus, if repeated exposure to semantic violations alleviates lexico-semantic processing difficulty, the magnitude of the N400 effect should have decreased during the experiment.

4.1 Method

The sentence in (4a) is semantically natural. In contrast, the sentence in (4b) is semantically anomalous because the verb "*naita*" (cried) takes an inanimate noun "*shikibo*" (music baton) as its subject in (4b). As in Experiment 1, we manipulated the probability of (un)grammatical sentences with filler sentences from Experiment 1. Thus, each list included 26 sentences for each condition, plus 60 filler sentences.

(4) a. Semantically natural sentence:
shinseiji-ga nai-ta.
baby-NOM cry-PST
"The newborn baby cried."
b. Semantic violation:
??shikibo-ga nai-ta.
baton-NOM cry-PST
"The baton cried."

Twenty native speakers of Japanese from Kyushu University took part in Experiment 3. We analyzed the N400 change using 300–500 ms mean amplitudes from the onset of verbs, recorded on the centroparietal regions (Cz, Pz, C3/4, P3/4, P7/8, and O1/2). The fixed factors were PROBABILITY (low/equal), VIOLATION (semantically natural/unnatural), and ITEM ORDER of each block with their interactions. The adaptation effect should have manifested as a significant three-way interaction, with the interaction of VIOLATION and ITEM ORDER being greater in the equal-probability block than in the low probability block.

4.2 Results

The main effect of VIOLATION was marginally significant ($\hat{\beta} = -1.55$, $t = -1.99$, $p = 0.05$). Importantly, however, we did not observe a significant interaction of PROBABILITY, VIOLATION, and ITEM ORDER ($\hat{\beta} = -0.90$, $t = -1.49$, $p > 0.10$) (Figure 4). Although visual inspection of Figure 4 suggests that the N400 effect was pronounced with increasing exposure, the interaction of VIOLATION and ITEM ORDER was not significant ($\hat{\beta}$ = −0.31, t = −1.51, p > 0.10). Therefore, there was no evidence in favor of adaptation to semantic violations.

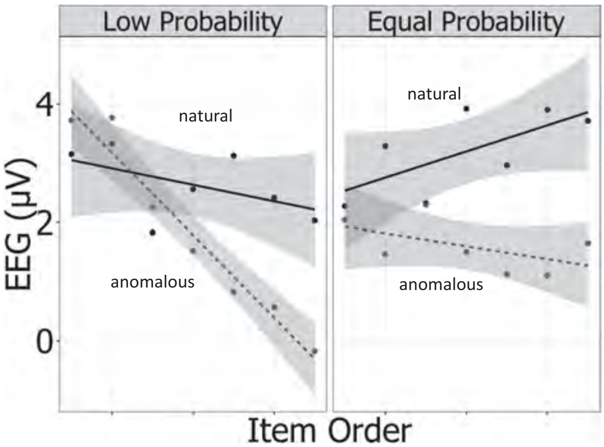

Figure 4: The N400 change in the low (left) and equal (right) probability blocks of Experiment 3. The x-axis denotes item order, and the y-axis denotes the amplitude of N400 in the 300–500 ms time window. Positivity is plotted upwards. Each line shows the N400 changes estimated by the LME models, and each dot indicates an N400 amplitude for every 20 trials. The gray areas refer to the 95% CI.

5 General discussion

Unlike morphosyntactic and aspectual violations, repeated exposure to semantic violations did not solve the processing difficulty associated with N400, which suggests limits to the adaptive behavior in language comprehension. The selective pattern implies that the language-processing system rationally decides whether to adapt to linguistic environments. Given that language communication usually takes place to exchange informative messages, it is plausible to think that people only adjust their expectations to what a reasonable speaker would say. For example, sentences such as "*The rose-ACC withered*" are morphosyntactically ill-formed, but the intended meaning is clear and semantically plausible. Aspectual coercion involves a resolvable mismatch; thus, it has a coherent interpretation in the first place. In contrast, semantic violations used in the present study are not sentences that a reasonable speaker would say. The intended meaning of the utterance is unrecoverable as it greatly deviates from comprehenders' expectations of what a speaker is likely to say. Therefore, comprehenders are less willing to adapt to semantic violations.

However, other factors are worth considering. First, Caffarra and Martin (2019) showed that native Spanish speakers exhibited a P600 effect for infrequent errors non-native speakers produced (subject-verb number disagreement) but not for frequent errors (gender disagreement), suggesting that the typicality of errors affects adaptation. In this case, semantic violations are far less typical than morphosyntactic and aspectual violations, thus requiring more solid evidence for the language-processing system to change the expectation (see also Nieuwland and Van Berkum 2006).

6 Conclusion

We investigated the flexible aspects of the language-processing system using ERPs. The findings suggest that native speakers of Japanese can rapidly adjust their expectations for morphosyntactic and aspectual violations. However, we found no evidence for adaptation to semantic violations. We argue that these differences reflect comprehenders' expectations of a message that a speaker is (un)likely to convey or the typicality of errors. As linguistic communication involves a joint activity between different interlocutors who have more or less different linguistic knowledge and preferences, linguistic adaptation works as a mechanism for cooperative alignment from the comprehenders' side.

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Chapter 8
(Dis)similarities between semantically transparent and lexicalized nominal suffixation in Japanese: An ERP study using a masked priming paradigm

1 Introduction

Two representative models have been proposed in psycholinguistic literature for the lexical processing of morphologically complex words: dual- and single-route models. The dual-route model presupposes that morphologically complex words are processed by two distinct mechanisms: rule and memory (Pinker and Prince 1988; Pinker 1999). The former mechanism (i.e., rule) explains the processing of complex words with regularity or productivity. For instance, an English regular past-tense verb "*worked,*" composed of two morphemes of the verb stem (*work*) and suffix (*-ed*), is recognized as the past-tense suffix attached to its stem. Conversely, the latter mechanism (i.e., memory) explains complex words that are irregular or unproductive (Stockall and Marantz 2006). For example, an English irregular past-tense verb "*fell,*" which does not have an apparent verb stem and past-tense suffix, is assumed to be memorized in the mental lexicon and recognized as a whole word form. Relative to the word *fell*, *worked* has an expectable rule-based form and its suffix *-ed* is productive in that it can attach to any other new verbs. Unlike sentence processing based on syntactic rules, word processing has characteristic features of regularity and productivity. Thus, the dual-route model is considered a plausible theory, supported by behavioral (Pinker 1991) and neurolinguistic studies (Pinker and Ullman 2002; Marslen-Wilson 2007).

Building on the dual-route model, a neurolinguistic study by Hagiwara et al. (1999) claims that this model can be applied to two types of de-adjectival nouns in

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Japanese (*-sa* noun: *yowa-sa*, weakness; *-mi* noun: *yowa-mi*, weak point). As with English examples, the former *-sa* noun is extremely productive and semantically transparent. However, the latter *-mi* noun is unproductive in that the nominal suffix *-mi* only attaches to a small set of adjectives with a monomorphemic stem (hence, we call these stems *-mi* type stems). Further, given the lexicalized meaning of *-mi* nouns, it is difficult to expect their meanings from their corresponding adjectives. In their studies, Hagiwara et al. (1999) reported that agrammatic Broca's aphasic patients showed challenges in producing *-sa* nouns, with little difficulty in *-mi* nouns. The other type of aphasic patients, especially the patients of Gogi (word-meaning) aphasia, showed the opposite pattern (i.e., challenges in producing *-mi* nouns). From the results, they concluded that these differences (or dissimilarities) reflected the two neurologically independent rule- and memory-based word-processing mechanisms, where the representation in the mental lexicon of *-sa* nouns is a stem and a suffix, while that of *-mi* nouns is a whole word (i.e., not decomposed into morphemes). They claimed that agrammatic aphasics showed impaired processing of *-sa* nouns because they cannot use a grammatical rule to combine a stem and a suffix. Despite their grammatical impairment, the patients could process *-mi* nouns, which are lexicalized and whose meaning can be understood without requiring the grammatical rule.

However, neurolinguistic studies on healthy people reported evidence for the single-route model, in which complex words are processed by a common mechanism regardless of their regularity and productivity. Two components of cortical activation have been investigated as hallmarks of how complex words are processed (i.e., M350 and M170) (M stands for magnetic). The M350 component is generated around 300–500 ms after the word onset in the middle temporal gyrus. The M350 comprises two subcomponents, at least, which reflect lexical access to morphemes and the recombination of morphemes (Pylkkänen and Marantz 2003). The other component, M170, is generated around 150–200 ms after the word onset in the left fusiform and inferior temporal gyri. It is considered that this component reflects the automatic decomposition of complex words. Using magnetoencephalography (MEG), Solomyak and Marantz (2010) reveal that the effect of lemma transition probability (TP) (probability of a suffix from the stem of a word) modulates the M350 component, while the surface frequency of a word does not affect it. From these results, they conclude that this activity reflects the processing of lexical access at the morpheme level but not the whole word level. In another MEG study, based on analyses of the M170 (i.e., an MEG component reflecting morphological decomposition), Fruchter, Stockall, and Marantz (2013) report larger activation for irregular past-tense forms than monomorphemic words (pseudo-irregular words); they conclude that the regular and irregular verbs are decomposed into morphemes in the same manner. These neurolinguistic studies suggest a common neural mechanism for the lexical processing of morphologically complex words, irrespective of the regularity or productivity of words.

Further, recent behavioral studies also provide inconsistent evidence for the dual-route model. In behavioral studies, the masked priming paradigm is widely applied to investigate the visual processing of morphologically complex words. In this paradigm, a priming word stimulus is presented on a screen extremely rapidly, followed by a target word. Rastle et al. (2000) report the facilitation of reaction time (RT) (priming effect) for morphologically related primes and targets (e.g., teacher-TEACH) but not semantically related pairs (e.g., cello-VIOLIN). Interestingly, this facilitation is also observed for morphologically unrelated but orthographically related pairs (e.g., brother-BROTH) (Rastle, Davis, and New 2004), suggesting that the masked priming paradigm can provide a situation where morphological effects are observed “in the absence of semantic effects” (Rastle et al. 2000: 517). Such priming effects reflect some process of decomposition that is different from morphological decomposition (i.e., “form-based [presemantic] processing”) (Rastle and Davis 2008; Morris and Stockall 2012). Moreover, Rastle, Davis, and New (2004) report that neither orthographically related controls (brothel-BROTH) nor orthographically similar pairs (boil-BROIL) showed the priming effects. Furthermore, Crepaldi et al. (2010) report that irregular verb pairs, such as fell-FALL, show a similar facilitating priming effect as regular verb pairs, while pseudo-irregular pairs (bell-BALL) did not. Such behavioral studies suggest that morphologically complex words are processed by primarily using morphological cues (i.e., identical morphemes between the prime and target). Orthographic cues (e.g., similarity of the letters) also play a role in the masked priming paradigm. However, it should be noted that orthographic cues alone cannot elicit the robust priming effect (e.g., brothel-BROTH).

In an MEG study, Lewis, Solomyak, and Marantz (2011) also demonstrate that only morpho-orthographically complex words enhance the amplitude of the M170, while the orthographically related control does not (brother vs. brothel). Moreover, using the masked priming paradigm, Fruchter, Stockall, and Marantz (2013) report that the masked priming effects on M170 activity were modulated by morpho-orthographically complex pairs and irregular verb pairs but not pseudo-irregular pairs (jumped-JUMP, fell-FALL vs. bell-BALL). Together, these results demonstrate that the masked priming paradigm and M170 allow for revealing the decomposition of morpho-orthographic properties for complex words (see also Gwilliams 2020).

In the event-related potentials (ERP) literature, the N400 and N170 are considered the electrophysiological analogs of the M350 and M170, respectively (e.g., Pylkkänen and Marantz 2003). The N400, reflecting lexical processes, is generated approximately 300–500 ms after the onset of words, while the N170, which reflects the automatic decomposition of complex words, is generated approximately 150–200 ms after. In an ERP study employing masked priming, Lavric, Clapp, and

Rastle (2007) report that morphologically related prime-target pairs attenuated the peak of the N400 in the parieto-occipital area, while orthographically related prime-target pairs did not. In an MEG study employing the masked priming paradigm, Fruchter, Stockall, and Marantz (2013) also report a difference in M350 cortical activation between morphologically related and unrelated pairs. The studies show that morpho-orthographically related prime-target pairs lighten the processing load of the target given the shared morpheme of these pairs being activated through priming. Hence, employing the masked priming paradigm in ERP studies is an effective way to investigate the processing of morphologically complex words. RTs and the N170 are indicators of morpho-orthographical decomposition. Moreover, the N400 will reflect semantic aspects of processing target complex words, which cannot be investigated by behavioral or N170 data.

A recent behavioral masked priming study on Japanese de-adjectival nouns for healthy adults shows robust masked priming effects on *-sa* and *-mi* nouns, suggesting that decomposition occurs while processing the two types of derived nouns (Clahsen and Ikemoto 2012). However, unlike many English studies on the mechanism of word processing, neurophysiological evidence has not yet been reported for Japanese.

Using electroencephalography (EEG), this chapter investigates the neural mechanism for processing complex words in the Japanese de-adjectival nouns by examining the ERP components, N400 and N170, crucial for lexical processing in the brain. We employ the masked priming paradigm to test the neural mechanism of morpho-orthographic and semantic aspects by behavioral and electrophysiological evidence. While it is beyond this study's scope to propose a comprehensive model of lexical processing of morphologically complex words (Embick, Creemers, and Goodwin Davies 2021), the primary aim is to more broadly demonstrate neurolinguistic evidence of processing of the two types of Japanese de-adjectival nouns. Based on recent neurolinguistic and behavioral studies, we test the hypothesis that the two types of Japanese de-adjectival nouns are processed by common neural mechanisms, especially in an earlier stage (i.e., morphological decomposition), proposed in prior neuroimaging studies in English past-tense verbs. With this hypothesis, the left-lateralized N170 will be observed in both de-adjectival nouns. Moreover, behavioral data for these de-adjectival nouns will show significant priming effects, and the N400 will be attenuated when the prime-target pairs have common stems (i.e., priming effects on the N400). Given their lexicalized meanings, we further hypothesize that *-mi* nouns will show a larger N400 peak than *-sa* nouns in the later stage, which reflects lexical access and recombination of morphemes.

This study focuses on following four prime-target conditions of *-mi* type stems to elucidate the morphological processing of transparent or lexicalized derived nouns: **Related condition of *-sa* nouns** (e.g., *yowa-i* → *yowa-sa*, weak → weakness),

unrelated condition of *-sa* nouns (e.g., *tura-i* → *yowa-sa,* stressful → weakness), **related condition of *-mi* nouns** (e.g., *yowa-i* → *yowa-m*i, weak → weak point), and **unrelated condition of *-mi* nouns** (e.g., *tura-i* → *yowa-mi*, stressful → weak point). Previous priming studies used more complex or derived words as primes (e.g., teacher-TEACH). However, this study uses derived nouns as targets because we want to examine behavioral and ERP data of the two types of de-adjectival nouns in Japanese, not the adjectives themselves. Moreover, to examine whether priming effects in behavioral and ERP data are independent of the conflict between the two types of de-adjectival nouns (*-sa* and *-mi* nouns), we include additional de-adjectival nouns that cannot derive *-mi* nouns ("non-*mi* type": e.g., *tura-sa*, stressfulness; *subaya-sa*, quickness) as stimuli.

2 Materials and methods

2.1 Participants

We recruited 19 right-handed native speakers of Japanese (seven males, mean ± standard deviation [SD]: 22.1 ± 2.2 yrs.). All participants provided written informed consent before participating in the study. One participant was excluded because of excessive artifacts in the EEG data; thus, 18 datasets were used for analysis (seven males, 22.0 ± 2.2 yrs.). All 18 participants showed right-handedness (laterality quotient: 88.9 ± 13.6), as determined by the Edinburgh Handedness Inventory (Oldfield 1971). All participants had normal or corrected-to-normal vision and no history of neurological or psychiatric disease. Approval for the experiments was obtained from the institutional review board of the Department of Linguistics, Faculty of Humanities, Kyushu University.

2.2 Stimuli

Based on adjectival stem frequencies, we selected 78 prime words from "Balanced Corpus of Contemporary Written Japanese" (BCCWJ, National Institute for Japanese Language and Linguistics, https://ccd.ninjal.ac.jp/bccwj/) (Maekawa et al. 2014). We created 156 target words by replacing the last syllable with *-sa* or *-mi*. The prime-target pairs were categorized into three groups, characterized by their stems (26 pairs each): *-mi* type stem (with a simple stem), non-*mi* type with a simple stem, and non-*mi* type with a complex stem. The *-mi* type stem condition allows for two types of derivation (e.g., *yowa-i* → *yowa-sa*, *yowa-mi*), while the non-*mi* type stems do not allow *-mi* suffixation (e.g., *tura-i* → *tura-sa*/**tura-mi*, stressful → stressfulness; *subaya-i* → *subaya-sa*/**subaya-mi*, quick → quickness). We created 156 nonce words by changing the last syllable(s) of the adjective *-i* to *-si-i*, or *-si-i* to *-i* (e.g., *yowa-i* (weak) → **yowa**si-i***; *kurusi-i* (distressed) → **kuru-**i***). We presented these stimuli (primes and targets) written in a combination of kanji (Chinese characters) and hiragana (Japanese syllabic characters), except for the following cases, which may elicit unexpected orthographic effects (see the Appendix for the list of the adjectives used). First, to avoid the ambiguity of reading, the word "辛さ," which could be read as *kara-sa* (spiciness) or *tura-sa* (stressfulness), was represented as "からさ" and "つらさ." Second, phonetic equivalents, kanji used as phonetic symbols rather than for their meanings, were also presented in hiragana. For example, "面白さ" was shown as "おもしろさ" (*omosiro-sa*, interest).[1] The same things applied to the following words: "おかしさ" (可笑しさ, *okasi-sa*, fun), "かわいさ" (可愛さ, *kawai-sa*, cuteness), and "気まずさ" (気不味さ, *kimazu-sa*, unpleasantness). Further, the words whose corresponding nonce words can be read as existing Japanese words were displayed in hiragana. For example, the corresponding nonce words of "苦しさ" was represented as "苦さ," which can be read as *niga-sa* (bitterness). Thus, this word was represented in hiragana ("くるしさ," *kurusi-sa*, distress). The same things applied to the following words: "にがさ" (苦さ, *niga-sa*, bitterness), "難しさ" (難しさ, *muzukasi-sa*, difficulty), and "わるさ" (悪さ, *waru-sa*, badness). Lastly, the word "とろさ" (*toro-sa*, stupidity/slowness) was displayed in hiragana, as this word cannot be written using kanji. Moreover, the unrelated condition of prime-target pairs with morphological relationships was excluded from stimuli (e.g., 早い–素早さ, *haya-i* and *subaya-sa*, early-quickness).

We compared the effects of length, surface frequency, and TP on ERP components as variables to examine the effects of word form and lexical properties on brain activity. The length of a word was defined by the number of letters. The mean values of these variables across the two conditions (*-sa* nouns and *-mi* nouns) did not show any significant differences (Table 1). Following Solomyak and Marantz (2010), we defined the lemma TP between the stem and suffix of each target word as follows: In calculating TP, Freq represents the lemma frequency of word form: TP(stem → suffix) = P(stem + suffix) / P(stem) $\propto$ Freq(stem + suffix) / Freq(stem). For instance, the calculation of TP (*yowa* → *-mi*) is represented as follows: P(*yowa-mi*) / P(*yowa-*) $\propto$ Freq(*yowa-mi*) / Freq(*yowa-*). We used the BCCWJ to calculate the lemma frequencies. For the following analyses, we used log-transformed frequencies and TP to reduce the skewness of the data distribution.

1 Two kanji, "面" and "白, " represent face/mask and white, respectively.

Table 1: Summary statistics for experimental stimuli.

Statistics	*-mi* type stems		*t* values	*p*-values
	-sa nouns	*-mi* nouns		
Log frequency (Prime)	3.57 ± 0.64	3.57 ± 0.64	N. A.	N. A.
Length (Target)	2.54 ± 0.80	2.54 ± 0.80	N. A.	N. A.
Log stem frequency (Target)	2.26 ± 0.08	2.54 ± 0.35	*t*(25) = 2.72	.11
Log transition probability (Target)	−1.44 ± 0.26	−1.75 ± 0.22	*t*(25) = 2.72	.10

Data are shown as mean ± standard deviation. A summary of two-tailed paired *t*-test between *-sa* nouns and *-mi* nouns. Note that the paired *t*-tests were not applicable (N. A.) for "log frequency (prime)" and "length (target)" because the same set of primes was used for *-sa* and *-mi* nouns, and the length of *-sa* and *-mi* nouns was always equivalent.

2.3 Procedures

We conducted a visual lexical decision task with masked priming, using PsychoPy 3.0.7, a psychophysics software program written in Python (Peirce 2007). The displayed fonts were Meiryo and Arial for Japanese characters and other letters, respectively. Each trial started with a fixation cross ("+") at the center of the screen for 500 ms, followed by a blank screen for 500 ms. A string of hash marks for 500 ms ("####") followed the blank screen, which served as a forward mask for the incoming prime word. The adjective prime word (e.g., 弱い, "*yowa-i,*" weak) was presented after the string of hash marks and remained for 48 ms; it was followed by the target word (e.g., 弱さ, "*yowa-sa,*" weakness; 弱み, "*yowa-mi,*" weak point) about which the participant was required to make a lexical decision. The target word was retained until the participant responded and was then replaced by a variable blank serving as an inter-trial interval. The inter-trial interval varied between 600–1200 ms. The primes and targets were presented in a random order for each participant (Figure 1).

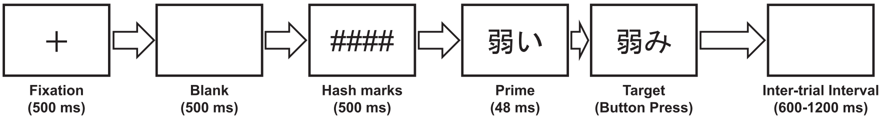

Figure 1: Experimental design using the masked priming paradigm. The participants performed a visual lexical decision task on the target words by pressing buttons.

During the experiment, the participants were seated in an electromagnetic shield room with a monitor positioned approximately 130 cm in front of them. They were instructed to judge whether the displayed letter strings were words by pressing buttons. The lexical decision task was preceded by 18 practice trials, which included feedback. Each participant took a short break approximately every five minutes during the experiment.

2.4 Electroencephalography acquisition

We acquired the EEG by fitting the participants with an elastic cap with 64 embedded Ag/AgCl electrodes (actiCAP, Brain Products; Neurofax EEG-1200, Nihon Kohden). Two additional AgCl electrodes were placed below and to the left of the left eye to monitor vertical and horizontal eye movements. The linked earlobes served as a reference. All electrode impedances were maintained below 45 kΩ throughout the experiments. The ERPs were amplified with a bandpass filter of 1–30 Hz and sampled at 1,000 Hz.

2.5 Data analyses

We used repeated-measures analyses of variance (rANOVAs) for behavioral and ERP data analyses. We considered a corrected *p*-value of less than 0.05 to be statistically significant in the following analyses. We applied the Greenhouse-Geisser correction for all effects involving more than one degree of freedom (Greenhouse and Geisser 1959, Picton et al. 2000) and corrected the multiple comparisons using Shaffer's modified sequentially rejective Bonferroni procedure (Shaffer 1986). For significant main effects with more than two levels, we conducted post-hoc pairwise comparisons using paired *t*-tests. We also ran simple effects tests for significant interactions. We reported the corrected degrees of freedom, corrected *p*-values, and effect sizes (Generalized eta squared [η^2_G] for ANOVA and Cohen's *d* for *t*-tests).

2.6 Behavioral data processing

We excluded trials with incorrect responses and results exceeding ±2.5 S.D. from the average (approximately 8.4% of the data) (Baayen 2008). We applied this exclusion procedure to the behavioral data. We conducted two independent analyses for the accuracy and RTs: A two-way rANOVA (**Prime Type [Related** and **Unrelated]** × **Suffix [*-sa*** and ***-mi*]**) for *-mi* type stem (e.g., *yowa-sa*, *yowa-mi*) to examine the priming effect of different de-adjectival nouns, and an additional two-way rANOVA (**Prime Type [Related** and **Unrelated]** × **Stem Type [-*mi* type stem**, **non-*mi* type with a simple stem**, and **non-*mi* type with a complex stem**]) for *-sa* nouns (e.g., *yowa-sa*, *tura-sa*, and *subaya-sa*; weakness, stressfulness, and quickness, respectively) to compare the priming effect of different stem types.

2.7 Event-related potentials data processing

We used MNE-Python for the ERP data analysis (Gramfort et al. 2013) and applied independent component analysis to de-noise the eyeblinks and ECGs. We computed ERP averages for a 600 ms time window under all conditions. The baseline was set to 100 ms before the stimulus onset. We excluded trials with incorrect responses and large artifacts exceeding 80 μV from further analysis (approximately 11.8% of the data).

For the analyses of the N400, epoched ERPs were averaged for the following seven regions of interest (**ROIs**): front central (**FC**: Fp1, Fp2, AF3, AFz, AF4, F1, Fz, F2), central (**C**: FC1, FC2, C1, Cz, C2, CP1, CPz, CP2), left frontal (**LF**: AF7, F7, F5, F3, FT9, FT7, FC5, FC3), right frontal (**RF**: AF8, F8, F6, F4, FT10, FT8, FC6, FC4), left temporal (**LT**: T7, C5, C3, TP9, TP7, CP5, CP3, P7, P5, P3), right temporal (**RT**: T8, C6, C4, TP10, TP8, CP6, CP4, P8, P6, P4), and parieto-occipital (**PO**: P1, Pz, P2, PO7, PO3, Pz, PO4, PO8, O1, Oz, O2, Iz) (Figure 2A). Following other masked priming studies of the N400/M350, the time window for the N400 was restricted to 300–500 ms (Morris and Stockall 2012; Fruchter, Stockall, and Marantz 2013). We ran a three-way rANOVA (**Prime Type [Related** and **Unrelated]** × **Suffix [*-sa*** and ***-mi*]** × **ROIs [FC**, **LF**, **C**, **RF**, **LT**, **RT**, and **PO]**) on the mean amplitude of the time window of the N400 to identify the ROIs in which the N400 differed between related and unrelated conditions. When significant main effects or interactions were found, we performed follow-up two-way rANOVA to assess the presence of priming effects in each condition.

For the analyses of the N170, epoched ERPs were averaged for the following five ROIs on the left, following Lavric, Clapp, and Rastle (2007): anterior frontal (**aF**: Fp1, AF3, AF7, F1, F3, F5, F7), posterior frontal (**pF**: FC1, FC3, FC5, FT7, FT9, C1, C3, C5), temporal (**T**: T7, CP5, TP7, TP9, P7), parietal (**P**: CP1, CP3, P1, P3, P5), and parieto-occipital (**PO**: PO3, PO5, O1). We also analyzed the corresponding regions on the right, while midline electrodes were not analyzed (Figure 2B). Following other studies of the N170/M170 (Morris, Grainger, and Holcomb 2013; Fruchter, Stockall, and Marantz 2013), the time window for the N170 was restricted to 150–200 ms. We conducted a two-way rANOVA (**Laterality [Left** and **Right]** × **ROIs [aF**, **pF**, **T**, **P**, and **PO]**) for the average amplitude of the N170 time windows to identify the

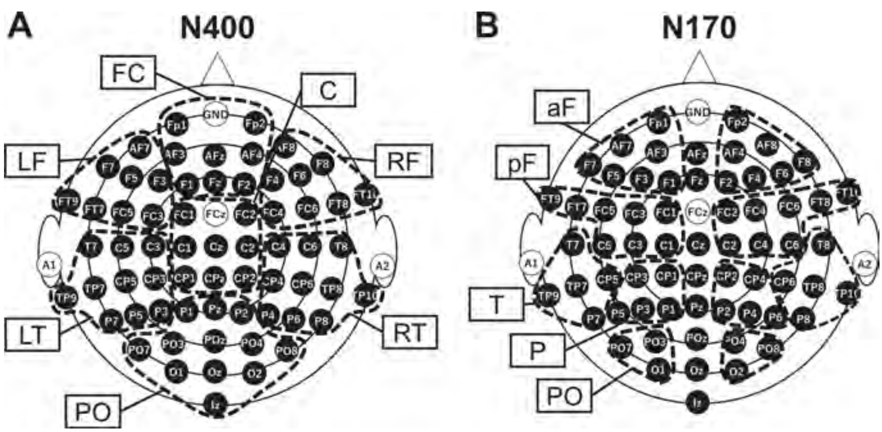

Figure 2: Regions of interest (ROIs) for the electroencephalography analyses. (**A**) ROIs for the N400. FC, fronto-central; C, central; LF, left frontal; RF, right frontal; LT, left temporal; RT, right temporal; PO, parieto-occipital. (**B**) ROIs for the N170. aF, anterior frontal; pF, posterior frontal; T, temporal; P, parietal; PO, parieto-occipital. We analyzed the corresponding regions on the right, while midline electrodes were excluded from the analyses.

generation source of the N170. When we found significant main effects or interactions between ROIs and laterality, we performed a follow-up rANOVA (**Prime Type** [**Related** and **Unrelated**] × **Suffix** [***-sa*** and ***-mi***]) to assess the presence of priming effects in each condition.

We conducted mixed-effects model analyses to examine the influence of individual target variables (i.e., TP, frequency, and length) on the moving average of a 5 ms change in millisecond-level amplitude over the time window of the N400. We used the lmer function in the lme4 package (Bates et al. 2015) and the clusterperm.lmer function in the permutes package of R (Voeten 2021).

Amplitude ~ length + TP + (1 | Subject)
Amplitude ~ length + frequency + (1 | Subject)

We used the above maximal feasible models, that is, the maximal model that is still capable of converging (Bates et al. 2018; Voeten 2021). Importantly, as TP is always less than one, log-transformed TP, which was used in linear mixed-effects modeling, is always a negative value (see 2.2 Stimuli for the definition of TP). Moreover, as the N400 is a negative-going potential, a positive regression coefficient (beta) in linear mixed-effects models for the TP indicates a larger N400, while a negative beta indicates a smaller N400.

We conducted two mixed-effects model analyses of ROI amplitude, with length and TP or frequency of individual targets as fixed factors and subjects as random factors. We used two formulas for the mixed-effects model analysis because of the high correlation between TP and frequency: one formula included TP and length as fixed effects, and the other formula included frequency and length as fixed effects. Considering the numerous regressions computed in the analysis, we performed a multiple comparison correction procedure (a permutation test following Maris and Oostenveld 2007) on the continuous moving average amplitude of the point-by-point regressions. We computed the beta values of fixed effects for 10,000 random permutations to identify temporal clusters in which the target variables were significantly correlated with the amplitude. We conducted this analysis separately for Prime Type (i.e., related and unrelated conditions) to probe the effect of priming on the ERPs.

3 Results

3.1 Behavioral results

Table 2 summarizes the behavioral data. The mean accuracy of the lexical decision task was 91.5%, indicating that the participants correctly performed the task. Regarding the accuracy, a two-way rANOVA (**Prime Type** × **Suffix**) showed a significant main effect of suffix for the *-mi* type stem [**Suffix**: $F(1, 17) = 29.06$, $p < .0001$, $\eta^2_G = .31$], suggesting that the participants had more difficulty with *-mi* nouns in the lexical decision task (Table 3). Conversely, the main effect of prime type and interaction was not significant [**Prime Type**: $F(1, 17) = 2.46$ $p = .14$, $\eta^2_G = .010$; **Interaction**: $F(1, 17) = 0.069$, $p = .80$, $\eta^2_G = .0004$].

Table 2: Behavioral data for stem types and conditions.

	***-mi* type stem (-*sa* nouns)**		***-mi* type stem (-*mi* nouns)**		**Non-*mi* type with a simple stem (-*sa* nouns)**		**Non-*mi* type with a complex stem (-*sa* nouns)**	
	Accuracy (%)	**RTs (ms)**	**Accuracy**	**RTs**	**Accuracy**	**RTs**	**Accuracy**	**RTs**
Related condition	96.4 ± 0.9	665 ± 25	86.1 ± 2.0	735 ± 32	95.3 ± 1.4	674 ± 25	86.8 ± 2.8	788 ± 32
Unrelated condition	95.1 ± 1.3	757 ± 31	84.2 ± 2.8	793 ± 34	94.0 ± 1.0	748 ± 27	81.4 ± 3.0	846 ± 32
Priming effect	1.3	−92	1.9	−58	1.3	−74	5.4	−58

Data are shown as mean ± standard error of the mean (SEM). The priming effect shows the subtraction of the mean accuracy and reaction times (RTs) between the unrelated and related conditions.

An additional two-way rANOVA (**Prime Type** × **Stem Type**) on the accuracy showed significant main effects of prime and stem types [**Prime Type**: $F(1, 17) = 11.87$, $p = .0031$, $\eta^2_G = .027$; **Stem Type**: $F(1.21, 20.6) = 17.74$, $p = .0002$, $\eta^2_G = .31$], while the interaction between prime and stem types was marginally significant [**Interaction**: $F(1.77, 30.03) = 2.92$, $p = .076$, $\eta^2_G = .014$] (Table 3). Multiple comparisons for the stem types showed that the non-*mi* type with a complex stem showed lower accuracy than other stem types [**-*mi* type vs. non-*mi* type with a complex stem**: $t(17) = 4.26$, corrected $p = .0009$, Cohen's $d = 1.24$; **Non-*mi* type with a simple stem vs. non-*mi* type with a complex stem**: $t(17) = 4.53$, corrected $p = .0009$, Cohen's $d = 1.12$], whereas the -*mi* and non-*mi* types with a simple stem showed no significant difference in accuracy [$t(17) = 1.02$, $p = .32$, Cohen's $d = 0.22$]. Post-hoc simple effects analyses for the significant interaction between the prime and stem types showed significant priming effects for the non-*mi* type with a complex stem but not for the other stem types [**-*mi* type**: $F(1, 17) = 1.31$, $p = .27$, $\eta^2_G = .019$; **Non-*mi* type with a simple stem**: $F(1, 17) = 1.31$, $p = .27$, $\eta^2_G = .016$; **Non-*mi* type with a complex stem**: $F(1, 17) = 9.48$, $p = .0068$, $\eta^2_G = .048$]. Multiple comparisons for the stem types under the related and unrelated conditions showed that the non-*mi* type with a complex stem was more challenging than other stem types [**Related**: **-*mi* type vs. non-*mi* type with a complex stem**: $t(17) = 3.66$, corrected $p = .0058$, Cohen's $d = 1.10$; **Non-*mi* type with a simple stem vs. non-*mi* type with a complex stem**: $t(17) = 3.45$, corrected $p = .0058$, Cohen's $d = 0.92$; **Unrelated**: **-*mi* type vs. non-*mi* type with a complex stem**: $t(17) = 4.48$, corrected $p = .0006$, Cohen's $d = 1.39$; **Non-*mi* type with a simple stem vs. non-*mi* type with a complex stem**: $t(17) = 4.72$, corrected $p = .0006$, Cohen's $d = 1.33$], whereas the -*mi* and non-*mi* types with a simple stem showed no significant difference [**Related**: **-*mi* type vs. non-*mi* type with a simple stem**: $t(17) = 0.75$, $p = .46$, Cohen's $d = 0.21$; **Unrelated**: **-*mi* type vs. non-*mi* type with a simple stem**: $t(17) = 0.72$, $p = .48$, Cohen's $d = 0.22$].

Table 3: Analysis of variance results of accuracy.

Factors	*df*	*F*	*p*	η^2_G
Prime Type × Suffix				
Prime Type	1, 17	2.46	.14	.010
Suffix	1, 17	29.06	<.0001	.31
Interaction	1, 17	0.069	.80	.0004
Prime Type × Stem Type				
Prime Type	1, 17	11.87	.0031	.027
Stem Type	1.21, 20.6	17.74	.0002	.31
Interaction	1.77, 30.03	2.92	.076	.014

df, degrees of freedom; η^2_G, generalized eta squared.

Regardless of the target conditions, the RTs were significantly facilitated when the morphologically related prime preceded the target (Table 2). For a two-way rANOVA (**Prime Type** × **Suffix**) of *-mi* type stem, we found facilitating priming effects for the related conditions [**Prime Type**: $F(1, 17) = 70.11$, $p < .0001$, $\eta^2_G = .080$] (Table 4). Additionally, we found the significant main effect of suffix [**Suffix**: $F(1, 17) = 30.92$, $p < .0001$, $\eta^2_G = .041$], showing that the RTs of *-mi* nouns were significantly longer than those of *-sa* nouns. However interaction between the prime types and suffixes was not significant [**Interaction**: $F(1, 17) = 2.23$, $p = .15$, $\eta^2_G = .0042$]. These results demonstrated that both types of nouns showed a morphological priming effect, and the effects between the two types of nouns were equivalent.

Table 4: ANOVA results of reaction times.

Factors	*df*	*F*	*p*	η^2_G
Prime Type × Suffix				
Prime type	1, 17	70.11	<.0001	.080
Suffix	1, 17	30.92	<.0001	.041
Interaction	1, 17	2.23	.15	.0042
Prime Type × Stem Type				
Prime Type	1, 17	160.2	<.0001	.090
Stem Type	1.87, 31.8	105.0	<.0001	.15
Interaction	1.88, 32.03	1.91	.17	.0032

df, degrees of freedom; η^2_G, generalized eta squared.

For the RT analysis of two-way rANOVA (**Prime Type** × **Stem Type**), robust priming effects were found in the related conditions [**Prime Type**: $F(1, 17) = 160.2$, $p < .0001$, $\eta^2_G = .090$] (Table 4). We also found a significant main effect of stem type [**Stem Type**: $F(1.87, 31.8) = 105.0$, $p < .0001$, $\eta^2_G = .15$], while the interaction between the prime and stem types was not significant [**Interaction**: $F(1.88, 32.03) = 1.91$, $p = .17$, $\eta^2_G = .0032$]. Multiple comparisons for the stem types showed that the non-*mi* type with a complex stem yielded longer RTs than other stem types [**-*mi* type stem vs. non-*mi* type with a complex stem**: $t(17) = 11.91$, corrected $p < .0001$, Cohen's $d = 0.80$; **Non-*mi* type with a simple stem vs. non-*mi* type with a complex stem**: $t(17) = 11.70$, corrected $p < .0001$, Cohen's $d = 0.84$], whereas the *-mi* type stem and non-*mi* type with a simple stem showed no significant difference for the RTs [**-*mi* type stem vs. non-*mi* type with a simple stem**: $t(17) = 0.013$, corrected $p = .99$, Cohen's $d = 0.0008$].

3.2 Event-related potentials results

3.2.1 Significant priming effects on the N400 for *-sa* and *-mi* nouns

The ERPs of the *-mi* type stem revealed attenuation of the N400 for the related condition relative to the unrelated condition in the C, LT, RT, and PO regions (Figure 3A). The scalp distribution of the unrelated – related contrast showed that the unrelated condition was more negative in both types of nouns (Figure 3B). A three-way rANOVA (**Prime Type** × **Suffix** × **ROIs**) for the *-mi* type stem of the mean amplitude of the N400 revealed significant main effects of prime type, suffix, and ROIs [**Prime Type**: $F(1, 17) = 20.96$, $p = .0003$, $\eta^2_G = .045$; **Suffix**: $F(1, 17) = 6.73$, $p = .019$, $\eta^2_G = .011$; **ROIs**: $F(1.74, 29.59) = 8.59$, $p = .0017$, $\eta^2_G = .13$] (Table 5). The interaction between prime type and ROIs was also significant [**Prime Type** × **ROIs**: $F(2.48, 42.24) = 28.28$, $p < .0001$, $\eta^2_G = .025$]. However, the other interactions were not significant [**Prime Type** × **Suffix**: $F(1, 17) = 0.11$, $p = .74$, $\eta^2_G = .0002$; **Suffix** × **ROIs**: $F(1.91, 32.54) = 1.17$, $p = .32$, $\eta^2_G = .0013$; **Prime Type** × **Suffix** × **ROIs**: $F(2.92, 49.68) = 1.91$, $p = .14$, $\eta^2_G = .0010$].

To determine conditions for further analyses, simple effects tests for significant interaction (i.e., prime type and suffix) were conducted. The effect of ROIs was significant regardless of prime type [**Related**: $F(1.87, 31.82) = 13.66$, $p = .0001$, $\eta^2_G = .19$; **Unrelated**: $F(1.7, 28.88) = 5.06$, $p = .017$, $\eta^2_G = .096$]. Prime type was significant only in the C, LT, RT, and PO regions [**C**: $F(1, 17) = 22.10$, $p = .0002$, $\eta^2_G = .059$; **LT**: $F(1, 17) = 24.27$, $p = .0001$, $\eta^2_G = .097$; **RT**: $F(1, 17) = 23.69$, $p = .0001$, $\eta^2_G = .066$; **PO**: $F(1, 17) = 61.41$, $p < .0001$, $\eta^2_G = .12$]; it was not significant in the FC, LF, and RF [**FC**: $F(1, 17) = 0.73$, $p = .40$, $\eta^2_G = .0032$; **LF**: $F(1, 17) = 2.85$, $p = .11$, $\eta^2_G = .010$; **RF**: $F(1, 17) = 1.17$, $p = .29$, $\eta^2_G = .0050$].

We conducted follow-up two-way rANOVAs (**Prime Type** × **Suffix**) for each of the C, LT, RT, and PO regions, which showed significant priming effects. Beyond the significant priming effects, we found a significant main effect of suffix in the C and LT [**C**: $F(1, 17) = 7.30$, $p = .015$, $\eta^2_G = .015$; **LT**: $F(1, 17) = 5.02$, $p = .039$, $\eta^2_G = .017$] (Figure 3C and Table 5). However, the RT and PO regions did not show a significant effect of suffix [**RT**: $F(1, 17) = 1.26$, $p = .28$, $\eta^2_G = .0043$; **PO**: $F(1, 17) = 1.81$, $p = .20$, $\eta^2_G = .0044$]. These results suggest that semantic processing regarding the lexicalized meaning of *-mi* nouns elicited the larger N400 in the C and LT regions. Interaction was not significant in all regions [**C**: $F(1, 17) = 0.0066$, $p = .94$, $\eta^2_G < .0001$; **LT**: $F(1, 17) = 0.48$, $p = .50$, $\eta^2_G = .0013$; **RT**: $F(1, 17) = 0.20$, $p = .66$, $\eta^2_G = .0003$; **PO**: $F(1, 17) = 0.52$, $p = .48$, $\eta^2_G = .0006$].

We further examined whether ERPs in the C, LT, RT, and PO regions for the non-*mi* types showed similar attenuation of the N400 for related conditions. Using two-way rANOVAs (**Prime Type** × **ROIs**), we found that the related condi-

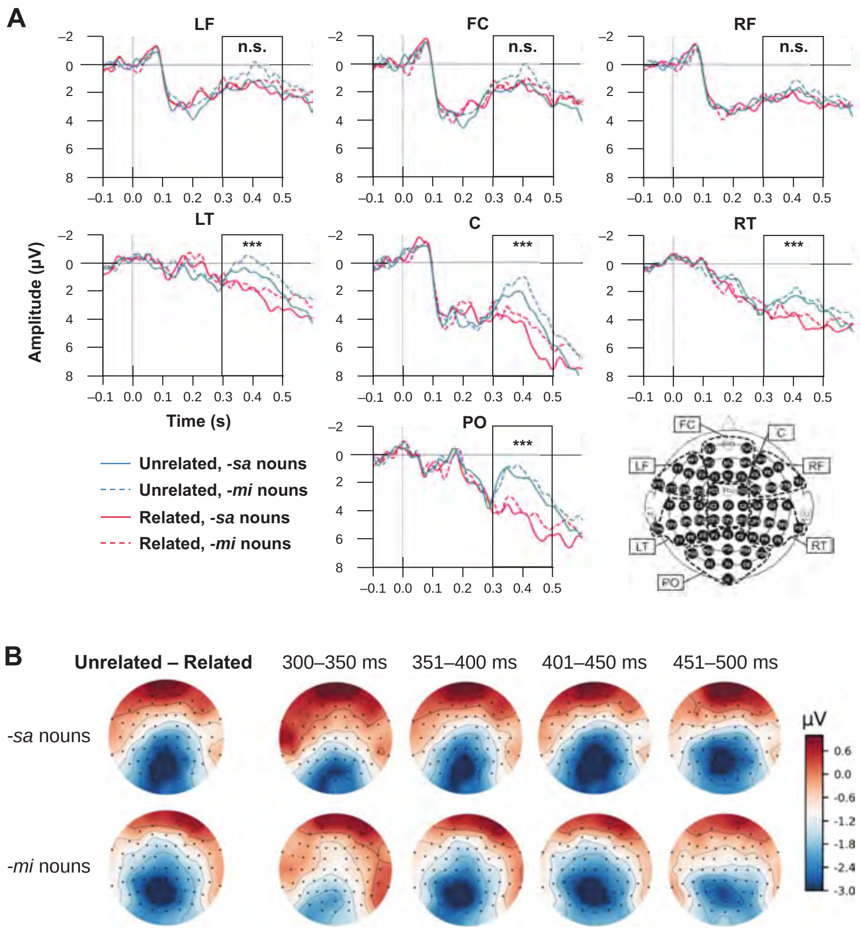

Figure 3: Significant priming effects on the N400. (**A**) Event-related potentials of the *-mi* type. Blue and red lines represent the unrelated and related conditions, respectively. Solid and dashed lines represent the *-sa* and *-mi* nouns, respectively. The rectangle areas (300–500 ms) indicate the time window of the N400. FC, fronto-central; C, central; LF, left frontal; RF, right frontal; LT, left temporal; RT, right temporal; PO, parieto-occipital. (**B**) The scalp distribution of the unrelated – related. (**C**) The amplitudes of the N400 (mean ± SEM). Filled and open bars denote the related and unrelated conditions, respectively. We applied the Greenhouse-Geisser correction for rANOVA and Shaffer's modified sequentially rejective Bonferroni procedure for the post-hoc tests. *corrected $p < .05$, **corrected $p < .01$, ***corrected $p < .001$.

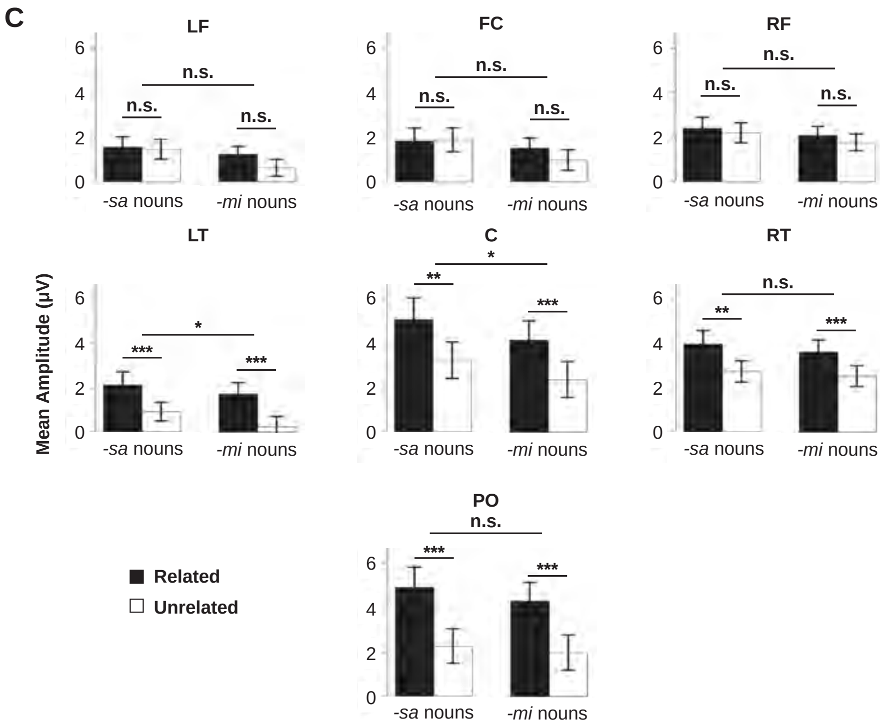

Figure 3 (continued)

Table 5: ANOVA results of the N400.

Factors	***df***	***F***	***p***	η^2_G
Prime Type × Suffix × ROIs				
Prime Type	1, 17	20.96	.0003	.045
Suffix	1, 17	6.73	.019	.011
ROIs	1.74, 29.59	8.59	.0017	.13
Prime Type × Suffix	1, 17	0.11	.74	.0002
Prime Type × ROIs	2.48, 42.24	28.28	<.0001	.025
Suffix × ROIs	1.91, 32.54	1.17	.32	.0013
Prime Type × Suffix × ROIs	2.92, 49.68	1.91	.14	.0010
C: Prime Type × Suffix				
Prime Type	1, 17	22.10	.0002	.059
Suffix	1, 17	7.30	.015	.015
Prime Type × Suffix	1, 17	0.0066	.94	<.0001

Table 5 (continued)

Factors	***df***	***F***	***p***	η^2_G
LT: Prime Type × Suffix				
Prime Type	1, 17	24.27	.0001	.097
Suffix	1, 17	5.02	.039	.017
Prime Type × Suffix	1, 17	0.48	.50	.0013
RT: Prime Type × Suffix				
Prime Type	1, 17	23.69	.0001	.066
Suffix	1, 17	1.26	.28	.0043
Prime Type × Suffix	1, 17	0.20	.66	.0003
PO: Prime Type × Suffix				
Prime Type	1, 17	61.41	<.0001	.12
Suffix	1, 17	1.81	.20	.0044
Prime Type × Suffix	1, 17	0.52	.48	.0006

df, degrees of freedom; η^2_G, generalized eta squared.

tion showed the attenuated peak of the N400 for the non-*mi* type stems [**Non-*mi* type with a simple stem**: $F(1, 17) = 21.19$, $p = .0003$, $\eta^2_G = .10$; **Non-*mi* type with a complex stem**: $F(1, 17) = 21.64$, $p = .0002$, $\eta^2_G = .14$] (Figure 4). Moreover, post-hoc comparisons between the related and unrelated conditions in each ROI showed significant priming effects in all regions [**Non-*mi* type with a simple stem**: **C**: $t(17) = 3.26$, corrected $p = .0046$, Cohen's $d = 0.77$; **LT**: $t(17) = 4.40$, corrected $p = .0011$, Cohen's $d = 1.04$; **RT**: $t(17) = 3.52$, corrected $p = .0052$, Cohen's $d = 0.83$; **PO**: $t(17) = 5.34$, corrected $p < .0001$, Cohen's $d = 1.34$; **Non-*mi* type with a complex stem**: **C**: $t(17) = 2.38$, corrected $p = .029$, Cohen's $d = 0.56$; **LT**: $t(17) = 3.56$, corrected $p = .0073$, Cohen's $d = 0.84$; **RT**: $t(17) = 3.34$, corrected $p = .0078$, Cohen's $d = 0.79$; **PO**: $t(17) = 3.78$, corrected $p = .0060$, Cohen's $d = 0.89$].

3.2.2 Attenuation of the N400 by transition probability

The linear mixed-effects model analyses revealed that the model including the TP between the stem and suffix as a fixed effect showed significant negative correlations for the unrelated conditions in two different time windows (Figure 5A). The correlation between the N400 amplitude and TP was significant in the C, LT, and PO regions around 330–370 ms, while at approximately 440–460 ms, the correlation was significant in the C, LT, RT, and PO regions (corrected $p < 0.05$). Given the negative regression coefficient (beta) in these regions, the results show that the TP between morphemes attenuated the amplitude of the N400, which is a crucial ERP

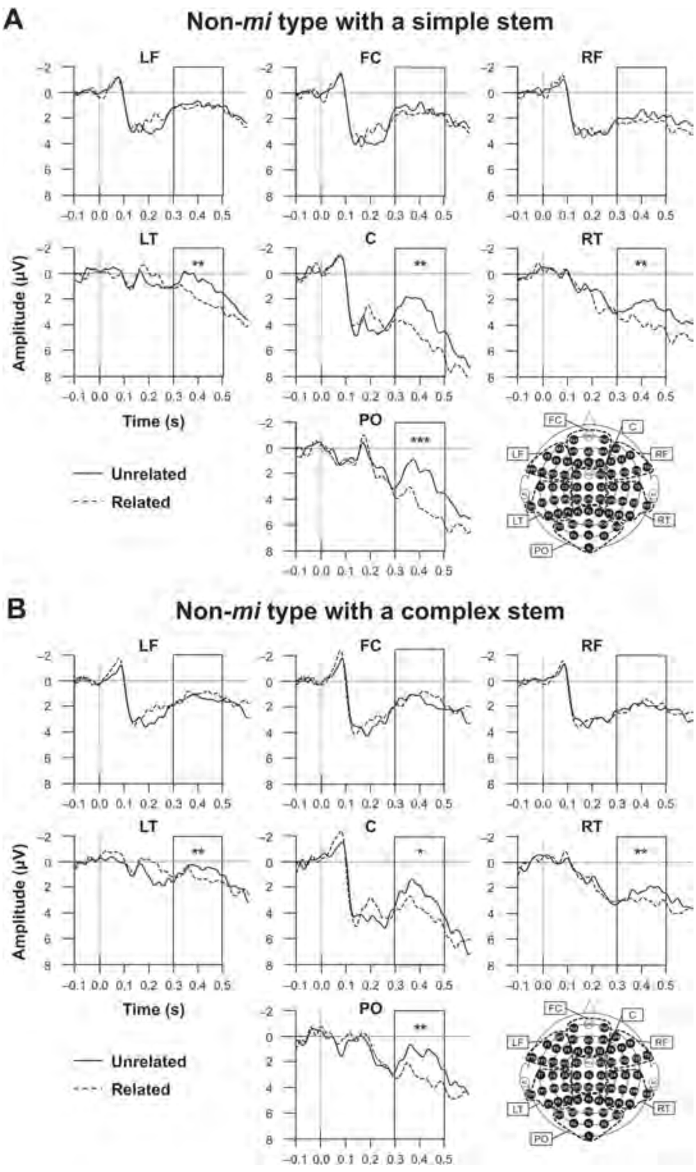

Figure 4: Event-related potentials (ERPs) of the non-*mi* types. (A) ERPs of the non-*mi* type with a simple stem and (B) ERPs of the non-*mi* type with a complex stem. Solid and dashed lines represent the unrelated and related conditions, respectively. The rectangle areas (300–500 ms) indicate the time window of the N400. FC, fronto-central; C, central; LF, left frontal; RF, right frontal; LT, left temporal; RT, right temporal; PO, parieto-occipital. We applied the Greenhouse-Geisser correction for rANOVA and Shaffer's modified sequentially rejective Bonferroni procedure for the post-hoc tests. *corrected $p < .05$, **corrected $p < .01$, ***corrected $p < .001$.

component for lexical access to morphemes and recombination of morphemes (see 2.7 Event-related potentials data processing for the relationship between the N400 and regression coefficient of TP). However, no significant correlations were found for the related condition (Figure 5B). We further tested another model including frequency as a fixed effect, which did not show a significant correlation in any regions or conditions throughout the N400 time window (300–500 ms).

3.2.3 Significant laterality effects on the N170

Among all four conditions, the scalp distribution of the N170 showed a lower amplitude in the left hemisphere than in the right hemisphere, indicating that the N170 component was localized in the left hemisphere (Figure 6A). A two-way rANOVA (**Laterality** × **ROIs**) revealed significant main effects for laterality and ROIs [**Laterality**: $F(1, 71) = 7.37$, $p = .0083$, $\eta^2_G = .0081$; **ROIs**: $F(1.76, 124.97) = 24.77$, $p < .0001$, $\eta^2_G = .084$] (Table 6). Additionally, the interaction between laterality and ROIs was also significant [**Interaction**: $F(2.42, 172.15) = 6.15$, $p = .0013$, $\eta^2_G = .0025$]. Multiple comparisons among the ROIs showed significantly lower amplitudes for the T and PO regions than for other regions [**T vs. aF**: $t(71) = 7.16$, corrected $p < .0001$, Cohen's $d = 0.81$; **T vs. pF**: $t(71) = 8.48$, corrected $p < .0001$, Cohen's $d = 0.70$; **T vs. P**: $t(71) = 4.09$, corrected $p = .0005$, $d = 0.34$; **PO vs. aF**: $t(71) = 5.06$, corrected $p < .0001$, Cohen's $d = 0.72$; **PO vs. pF**: $t(71) = 5.94$, corrected $p < .0001$, Cohen's $d = 0.65$; **PO vs. P**: $t(71) = 5.99$, corrected $p < .0001$, Cohen's $d = 0.37$]. However, post-hoc analysis revealed no significant difference between the mean amplitudes of T and PO [$t(71) = 1.19$, corrected $p = .48$, Cohen's $d = 0.10$]. Comparing the ERPs of these regions, a clear sharp peak was found in the PO region of the left hemisphere (Figure 6B). We found significant laterality effects on the N170 in the T and PO regions [**T**: $t(71) = 2.56$, corrected $p = .013$, Cohen's $d = 0.30$; **PO**: $t(71) = 3.32$, corrected $p = .0028$, Cohen's $d = 0.39$].

A follow-up rANOVA (**Prime Type** × **Suffix**) was performed for PO in the left hemisphere. No significant main effects of prime type and suffix or interaction were found [**Prime Type**: $F(1, 17) = 0.038$, $p = .85$, $\eta^2_G = .0006$; **Suffix**: $F(1, 17) = 0.011$, $p = .92$, $\eta^2_G = .0002$; **Interaction**: $F(1, 17) = 0.079$, $p = .78$, $\eta^2_G = .0011$] (Table 6). These results indicated that the target *-sa* and *-mi* nouns were processed similarly in this time window, even if the nouns were preceded by morphologically related primes. Further, the linear mixed-effects model analyses of the left PO amplitude found no significant temporal cluster regardless of TP or frequency (corrected $p > .05$), indicating that TP and frequency did not modulate the amplitude of the N170.

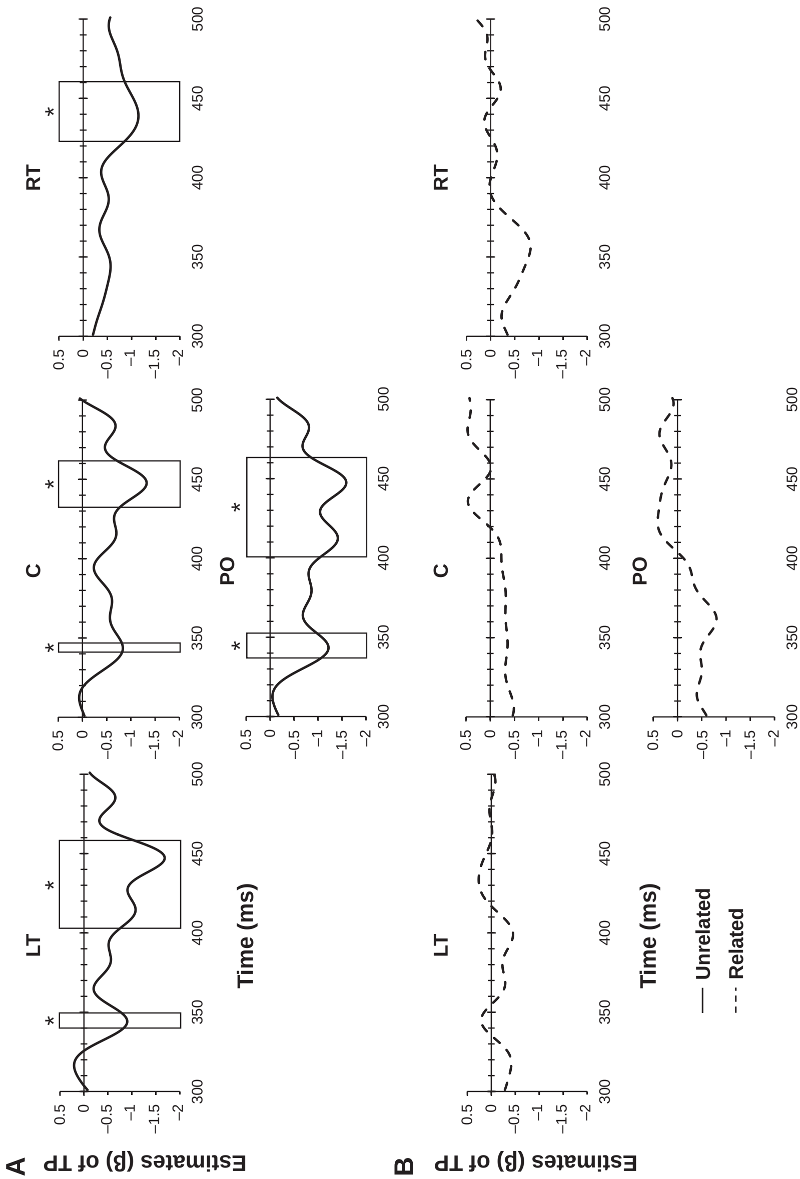

Figure 5: Effect of the transition probability between stem and suffix in the N400 region. Related condition (**A**) and unrelated condition (**B**). The rectangle areas indicate significant temporal clusters (corrected $p < 0.05$). C, central; LT, left temporal; RT, right temporal; PO, parieto-occipital. We performed a multiple comparison correction procedure on the continuous moving average amplitude of the point-by-point regressions using a permutation test. *corrected $p < .05$.

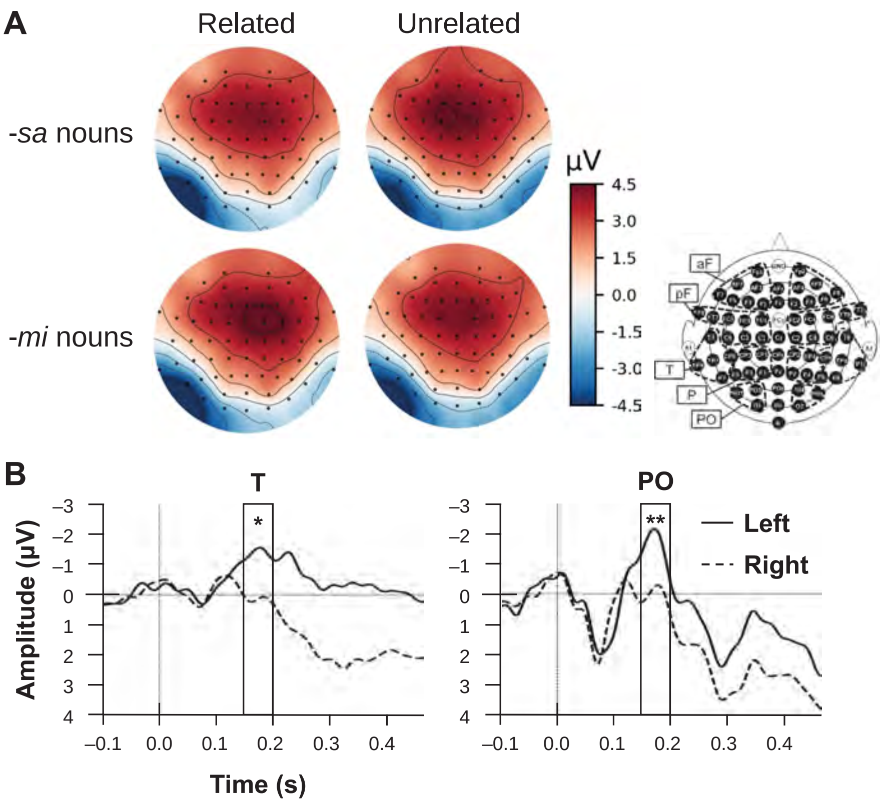

Figure 6: Significant laterality effects on the N170 in the temporal (T) and parieto-occipital (PO) regions. (**A**) Averaged N170 (150–200 ms) scalp distributions of the four conditions (Prime Types × Suffix). The N170 was more negative-going in the left T and PO regions. (**B**) Event-related potentials (ERPs) of the T and PO regions. Solid and dashed lines represent ERPs of the left and right hemispheres, respectively. The rectangle areas indicate the time window of the N170 (150–200 ms). We applied the Greenhouse-Geisser correction for rANOVA and Shaffer's modified sequentially rejective Bonferroni procedure for the post-hoc tests. *corrected $p < .05$, **corrected $p < .01$.

Table 6: ANOVA results of the N170.

Factors	***df***	***F***	***p***	η^2_G
Laterality × ROIs				
Laterality	1, 71	7.37	.0083	.0081
ROIs	1.76, 124.97	24.77	<.0001	.084
Interaction	2.42, 172.15	6.15	.0013	.0025

Table 6 (continued)

Factors	*df*	*F*	*p*	η^2_G
PO: Prime Type × Suffix				
Prime Type	1, 17	0.038	.85	.0006
Suffix	1, 17	0.011	.92	.0002
Interaction	1, 17	0.079	.78	.0011

df, degrees of freedom; η^2_G, generalized eta squared.

4 Discussion

In the present ERP study using the masked priming paradigm (Figure 1), we obtained three striking results by examining the N400 and N170 components of two types of Japanese-derived nouns—semantically transparent *-sa* nouns and lexicalized *-mi* nouns (Table 7). First, we demonstrated the significant priming effects on the N400, as well as the significant laterality effects on the N170, for *-sa* and *-mi* nouns (Figures 3, 4, and 6; Tables 5 and 6). These results suggest that morphologically complex words were processed by a common neural mechanism (i.e., similarity). Moreover, we found a larger N400 and lower behavioral performance (lower accuracy and longer RTs) for *-mi* nouns given their lexicalized meaning (i.e., dissimilarity). Second, by using the linear mixed-effects models, we show that the TP from stem to suffix and the amplitude of the N400 showed significant negative modulations in the LT, C, RT, and PO (corrected $p < .05$) (Figure 5). These results indicate that the TP attenuates the amplitude of the N400. Third, both types of derived nouns showed significant morphological priming effects in the behavioral data; that is, shorter RTs and lower error rates under the related condition (Tables 2, 3, and 4). These results support similar neural mechanisms for processing the two derived noun types. However, behavioral data also indicate that *-mi* nouns were more demanding than *-sa* nouns, further suggesting the dissimilarity of processing mechanisms for these de-adjectival nouns.

In the rANOVAs of the N400 for the factor of prime type, we found a significantly lower mean amplitude for the unrelated condition in the ROIs of C, LT, RT, and PO (Figure 3A and 3C, Table 5). These results show that the N400 was attenuated under the related condition, consistent with a previous masked priming ERP study (Lavric, Clapp, and Rastle 2007). As the masked prime activates the lexical entry of morphemes, these results also suggest the morphological relation between a prime adjective and a target *-sa*/*-mi* noun (i.e., both target *-sa* and *-mi* nouns share a common adjectival stem with the prime adjective). As was reported in prior ERP studies (Lavric, Clapp, and Rastle 2007; Morris and Stockall 2012), the results suggest that the common morpheme (i.e., stem) in the prime adjective and

Table 7: Summary of similarities and dissimilarities between *-sa* and *-mi* nouns.

	Similarities	Dissimilarities
Accuracy	—	*-sa* > *-mi*
RTs	Priming effects: Related < Unrelated	*-sa* < *-mi*
N400	Priming effects: Related < Unrelated	*-sa* < *-mi*
N170	Laterality effects: Left > Right	—

Behavioral data showed lower behavioral performance for *-mi* nouns than *-sa* nouns. We found significant priming effects (attenuation of the N400) for both de-adjectival nouns, while the N400 was larger for *-mi* nouns. The N170 showed significant laterality effects for *-sa* and *-mi* nouns.

the target de-adjectival noun was activated in the parieto-occipital area. Notably, the non-*mi* type stem showed similar attenuation of the N400 for related conditions (Figure 4). Intriguingly, we found a larger N400 for *-mi* nouns in the C and LT regions (Figure 3C), indicating that the lexicalized meaning of *-mi* nouns elicited higher loads for semantic processing, consistent with previous studies (Hagiwara et al. 1999; Clahsen and Ikemoto 2012). These results demonstrate the similarities and dissimilarities between *-sa* and *-mi* noun processing mechanisms.

In the mixed-effects model analyses of the N400, we found two significant temporal clusters in which the TP negatively modulated the N400 under the unrelated condition (Figure 5). However, the surface frequency did not have such a modulatory effect. This result implies that both types of derived nouns are dealt with as morphemes (stems and suffixes) but not whole word forms. Further, the lack of temporal clusters in the related condition implies that the attenuated peak of the N400 in Figure 3A reflected the lower processing loads of morphological decomposition of the de-adjectival nouns. A previous study of the N400 component evoked by word processing suggests that there are some subcomponents in the N400 time window (Pylkkänen and Marantz 2003). Moreover, MEG studies that address the M350 demonstrate that the M350 reflects two stages of the lexical process: lexical access and recombination of morphemes (Fruchter and Marantz 2015; Neophytou et al. 2018; Stockall et al. 2019). Therefore, the two temporal clusters in this study may correspond to two different stages of the lexical process. Importantly, linear mixed-effects modeling showed a negative beta value for the TP for each temporal cluster. That is, as a larger N400 peak indicates a higher processing load for the target, it demonstrates that when the target TP is smaller, the following suffix becomes more challenging for readers to predict. The results show that derived nouns are represented as stems and suffixes, even for the *-mi* nouns, which contradicts Hagiwara et al. (1999) who postulated no decomposition.

In the behavioral data, we found robust priming effects in both types of nouns (Tables 2, 3, and 4), which replicates the findings of Clahsen and Ikemoto (2012). As semantic priming does not occur in the masked priming paradigm, the priming effect can reflect the morpho-orthographical relation between prime and target (Frost, Foster, and Deutsch 1997; Rastle et al. 2000). Intriguingly, the *-mi* nouns showed longer RTs and larger N400 (Figure 3C), which reflects lexical access and morphological recombination, relative to the *-sa* nouns. The results demonstrate that a difference in semantic transparency can be observed at the behavioral and later neural level (i.e., >300 ms: the N400 time window in our study), not at the earlier neural level (i.e., <200 ms: the N170 time window in our study). This interpretation can also explain the behavioral dissociation of *-sa* and *-mi* nouns for agrammatic aphasic patients (Hagiwara et al. 1999).

For the N170 component, which reflects morpho-orthographical decomposition, the rANOVA of ERPs shows a sharp and significantly lower peak in the left PO region (Figure 6B). This result suggests that both noun types were decomposed into stems and suffixes. Further, there is no significant difference between *-sa* and *-mi* nouns or between related and unrelated conditions (Figure 6A and Table 6). The results further suggest that the target nouns are processed in the same manner, regardless of the noun or prime type.

The study demonstrated results contrary to prior studies using cross-modal priming in English and aphasic studies, supporting the dual mechanism theory (Marslen-Wilson 1993; Hagiwara et al. 1999). The inconsistent results may stem from differences in the experimental paradigm. Prior studies employed auditory and visual stimuli or required production and comprehension, while this study employed visual stimuli and required comprehension alone (Figure 1). Moreover, we recruited a relatively small number of participants (n = 18) who could explain the lack of priming effect for the N170 (Figure 6A and Table 6), as reported in the previous MEG study (Fruchter, Stockall, and Marantz 2013). Future studies can consider recruiting more participants.

An essential topic in psycho-neurolinguistics is whether morphological processing (e.g., morphological decomposition, lexical access, and recombination) is universal among languages. As most of the prior studies targeted English, it is important to probe morphological processing in typologically different languages, including Japanese. For example, the previous MEG study examined morphological processing in Japanese verbs and found that morphologically complex causative verbs elicited the N170, suggesting morphological decomposition (Ohta, Oseki, and Marantz 2019). Recent MEG studies also reported similar results in different languages (Finnish: Hakala et al. 2018; Greek: Neophytou et al. 2018; Hebrew: Kastner, Pylkkänen, and Marantz 2018; and Tagalog: Wray, Stockall, and Marantz 2022). As with such studies, the ERP study helps elucidate the neural basis of morphological processing (Table 7). As noted by Embick, Creemers, and Goodwin Davies (2021: 95), whether words are decomposed is too coarse-grained to guide the development of competing morphological theories. Future studies must probe more fine-grained research questions to contribute insight into the neural basis of morphological processing (Embick and Poeppel 2015).

Whether morphology differs from syntax is another critical issue in theoretical and experimental linguistics. A recent MEG study reported a common neural activation for building compounds and phrases in the left temporal lobe (Flick et al. 2018; see also Gwilliams 2020), although whether the left frontal language area activates during the morphological processing remained unclear. Prior fMRI studies show that the left inferior frontal gyrus is a core region for syntactic computation (Ohta, Fukui, and Sakai 2013a, 2013b; Ohta, Koizumi, and Sakai 2017; Tanaka et al. 2017; Tanaka et al. 2019), suggesting that this region is essential to morphological processing. Further research must examine the function of the left inferior frontal gyrus in morphological processing.

This study aimed to bridge the gap in the neurophysiological evidence for processing morphologically complex words. We hypothesize a common mechanism for two types of Japanese de-adjectival nouns and show this in an ERP study employing a masked priming paradigm. In the ERP analyses, the ERP components—N170 and N400—show that the neural processes between the two types of nouns are driven by a common mechanism (Figures 3, 5, and 6; Tables 5 and 6). It accords with studies of complex word processing in English. Moreover, we also found a larger N400 for *-mi* nouns, given their lexicalized meaning (Figure 3C), suggesting the dissimilarity of the neural mechanism for processing two types of de-adjectival nouns. In particular, we elucidate where and when the variables of nouns modulate each ERP component by applying mixed-effects models (Figure 5). The modeling shows two separate stages of the lexical process, which can be explained by the TP between morphemes. In the behavioral analyses, we find a robust priming effect for the two types of nouns (Tables 2, 3, and 4), which also supports our hypothesis. Although further evidence is required to establish a more detailed mechanism for word recognition, the neural and behavioral results clearly showed a common processing mechanism of the two types of derived nouns in the earlier stage (i.e., morphological decomposition) (Table 7). In the later stage, which reflects lexical access and recombination of morphemes, different neural mechanisms processed the two types of de-adjectival nouns (Table 7). The results show the similarities and dissimilarities of the neural mechanisms, which were also proposed in the past-tense debate in English, for processing two types of de-adjectival nouns in Japanese. By demonstrating that the Japanese word-processing mechanism accords with that of typologically different languages, this study contributes to elucidating the cross-linguistic universality of the neural basis of morphological processing.

Appendix. The list of the adjectives used in this study

-*mi* type stem	**Non-*mi* type stem (simple stem)**	**Non-*mi* type stem (complex stem)**
aka-i (赤い, red)	*atarasi-i* (新しい, new)	*aoziro-i* (青白い, pale)
akaru-i (明るい, bright)	*haya-i* (早い, early)	*araarasi-i* (荒々しい, violent)
ama-i (甘い, sweet)	*hido-i* (酷い, horrible)	*bakabakasi-i* (馬鹿馬鹿しい, ridiculous)
ao-i (青い, blue)	*hiku-i* (低い, low)	*buatu-i* (分厚い, thick)
atataka-i (温かい, warm)	*hiro-i* (広い, spacious)	*habahiro-i* (幅広い, broad)
atu-i (厚い, thick)	*huru-i* (古い, old)	*hadazamu-i* (肌寒い, chilly)
huka-i (深い, deep)	*kata-i* (固い, hard)	*hodotoo-i* (程遠い, far away)
ita-i (痛い, painful)	*kawai-i* (かわいい, cute)	*hosonaga-i* (細長い, long and thin)
kanasi-i (悲しい, sad)	*kowa-i* (怖い, scary)	*kandaka-i* (甲高い, high-pitched)
kara-i (からい, spicy)	*kura-i* (暗い, dark)	*kiiro-i* (黄色い, yellow)
kayu-i (痒い, itchy)	*mizika-i* (短い, short)	*kimazu-i* (気まずい, unpleasant)
kurusi-i (くるしい, distressed)	*muzukasi-i* (むずかしい, difficult)	*kodaka-i* (小高い, slightly elevated)
kusa-i (臭い, smelly)	*naga-i* (長い, long)	*kokoroboso-i* (心細い, lonely)
maru-i (丸い, round)	*oisi-i* (おいしい, tasty)	*monosugo-i* (物凄い, tremendous)
niga-i (にがい, bitter)	*oo-i* (多い, many/much)	*musiatu-i* (蒸し暑い, hot and humid)
okasi-i (おかしい, funny)	*ooki-i* (大きい, large)	*nadaka-i* (名高い, renowned)
omo-i (重い, heavy)	*oso-i* (遅い, late/slow)	*namanamasi-i* (生々しい, graphic/vivid)
omosiro-i (おもしろい, interesting)	*sukuna-i* (少ない, few/little)	*nezuyo-i* (根強い, deep-rooted)
sibu-i（渋い, astringent)	*tiisa-i* (小さい, small)	*okubuka-i* (奥深い, profound)
sitasi-i (親しい, friendly)	*too-i* (遠い, distant)	*sikaku-i* (四角い, square)
sugo-i (凄い, fantastic)	*tura-i* (つらい, stressful)	*subaya-i* (素早い, quick)
taka-i (高い, high)	*uresi-i* (嬉しい, happy)	*teatu-i* (手厚い, hospitable)
toro-i (とろい, stupid/slow)	*usu-i* (薄い, thin)	*tebaya-i* (手早い, speedy)
tuyo-i (強い, strong)	*waka-i* (若い, young)	*tyairo-i* (茶色い, brown)
uma-i (旨い, tasty)	*waru-i* (わるい, bad)	*usugura-i* (薄暗い, dim)
yowa-i (弱い, weak)	*yasu-i* (安い, cheap)	*yowayowasi-i* (弱々しい, faint)

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Chapter 9
Brain mechanisms for the processing of Japanese subject-marking particles *wa*, *ga*, and *no*

1 Introduction

Advances in neuroimaging techniques, such as functional magnetic resonance imaging (fMRI), have incited neurolinguists to identify the brain regions responsible for syntactic structure-building during online sentence processing. The literature has shown that the left inferior frontal gyrus (IFG) and the posterior part of the left temporal cortex, traditionally called Broca's and Wernicke's areas, are responsible for several aspects of language processing (Price 2012). Recent meta-analyses of fMRI studies suggest that the IFG and the posterior temporal cortex in the left hemisphere are crucial for syntactic processing (Heard and Lee 2020; Rodd et al. 2015; Zaccarella, Schell, and Friederici 2017). Moreover, some studies have highlighted functional subregions involved in different aspects of syntactic processing such as syntactic reanalysis (Hirotani et al. 2011) and online structure-building (Zaccarella, Schell, and Friederici 2017). However, current fMRI evidence may be biased toward well-studied Western languages such as English or German (see the cited meta-analysis studies above). Though Japanese is a relatively well-studied Asian language, many aspects of its unique syntactic features remain unexplored.

Consider, for example, how a sentence is syntactically parsed in real-time. One of the most fundamental aspects of structure-building is to establish the relations between arguments and predicates. Regarding online incremental processing, the verb plays a significant role in a Subject-Verb-Object language, such as English, because it is available at an early stage of incremental structure-building, determining what comes in the rest of the sentence. Thus, the structure-building is *verb-*

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driven, as the verb, along with its subject, plays a significant role in foreseeing incoming arguments and adjuncts (Gorrell 1995; Kamide, Altmann, and Haywood 2003; Pritchett 1992). In contrast, in a Subject-Object-Verb (SOV) language, such as Japanese, all the arguments and adjuncts precede the verb, which makes the incremental structure-building largely done before the verb is encountered; thus, structure-building is considered *argument-driven* (Kamide and Mitchell 1999; Kamide, Altmann, and Haywood 2003). Hence, particles attached to noun phrases (NPs) play significant roles in structure-building in that they can incrementally assign a proper syntactic structure to the inputs. However, only a few fMRI studies have probed the neural bases of the processing of Japanese particles (Hashimoto, Yokoyama, and Kawashima 2014; Inui, Ogawa, and Ohba 2007), and how different particles recruit brain regions related to syntactic processing has rarely been explored.

Accordingly, this study focused on the processing of three variants of subject-marking particles in Japanese, as they may drive distinct structure-building or syntactic reanalysis with a minimum impact on the semantic content of a sentence. As shown in (1), Japanese subjects can be marked by particles such as the topic particle *wa*, the nominative particle *ga*, and the genitive particle *no*.[1] On the incremental structure-building, this chapter assumed that the different subject-marking particles drive syntax-related activation differently. We conducted two fMRI experiments with pairs of *wa*- and *ga*-marked subjects and pairs of *ga*- and *no*-marked subjects, each for which we compared the activations resulting from different subject-marking particles. The next section briefly introduces some theoretical assumptions regarding the three subject-marking particles.

(1) a. Subject with *wa*

Taro-wa	*Mari-o*	*tataita.*
Taro-TOP	Mari-ACC	Hit

“Taro hit Mari.”

b. Subject with *ga*

Taro-ga	*Mari-o*	*tataita.*
Taro-NOM	Mari-ACC	Hit

“Taro hit Mari.”

1 These particles are not exclusively used as a subject marker and can mark other elements in a sentence, such as an object. In addition, Japanese subjects can be marked with other particles, such as the dative particle *ni*:

Taro-ni	eigo-ga	dekiru.
Taro-DAT	English-NOM	can.do

“Taro can speak English.”

c. Subject with *no*

Taro-no	*kaita*	*Hon*
Taro-GEN	wrote	Book

"The book that Taro wrote"

1.1 Subjects with wa and ga

Notably, *wa* can be used as a thematic or contrastive topic marker (Kuno 1973). In this chapter, we focused on the non-contrastive use of *wa*, as in (1a), widely recognized as a topic marker. In the literature on generative syntax, there is a consensus that the syntactic position of the *wa*-marked subject as a thematic topic is higher than that of the *ga*-marked subject, adding a structural layer. The clausal structure shown in (2) has been proposed from the perspective of the cartographic approach to the left-periphery (Rizzi 1997), and the *wa*-marked subject is often assumed to be in the Spec of TopP (Endo 2007; Miyagawa 2017; Nakamura 2020), while the *ga*-marked subject is in the Spec of TP:

(2) [TopP [TP [*v*P [VP]]]]

Evidently, only one psycholinguistic study examined the difference in processing costs between topicalized sentences (i.e., *wa*-marked SOV: S_{TOP}OV) and non-topicalized counterparts (i.e., *ga*-marked SOV, S_{NOM}OV). Imamura, Sato, and Koizumi (2016) examined whether sentences with a topicalized *wa*-marked subject were more cognitively demanding than those with a non-topicalized *ga*-marked subject. They used a semantic correctness decision task during which participants were required to judge whether a presented sentence was semantically plausible; they found no significant differences in error rates and reaction times between those types of sentences. They interpreted the results to reflect a trade-off between a lower frequency of S_{NOM}OV than that of S_{TOP}OV and a more complex syntactic hierarchy of S_{TOP}OV than that of S_{NOM}OV. To date, no study has provided direct evidence of the increased syntactic cost of S_{TOP}OV relative to that of S_{NOM}OV. This study examined whether *wa*-marked subjects, relative to *ga*-marked ones, induced increased activation in brain regions related to syntactic structure-building.

1.2 Subjects with ga and no

Syntactic properties of subjects with *ga* and *no* have been extensively studied in the literature on theoretical syntax, wherein various syntactic conditions have been identified for *no*-marked subjects but not for *ga*-marked subjects (e.g. Harada 1971; Hiraiwa 2005; Miyagawa 2011; Watanabe 1996; see also, Maki and Uchibori 2008 and Ochi 2017 for an overview).[2] For example, while *no*-marked subjects typically appear in relative clauses, as in (1c), they cannot appear in matrix and some subordinate clauses, as in (3).

(3) a. Subject in a main clause

*Taro-ga/*no*	*Mari-o*	*tataita.*
Taro-NOM/GEN	Mari-ACC	Hit

"Taro hit Mari."

b. Subject in a subordinate clause with complementizer *to*

*Taro-ga/*no*	*Mari-o*	*tataita-to*	*kiita.*
Taro-NOM/GEN	Mari-ACC	hit-COMP	heard

"(I) heard that Taro hit Mari."

Among various syntactic restrictions of *no*-marked subjects discussed in the literature, the present chapter focused on the adjacency constraint, whereby the acceptability of *no*-marked subjects is said to be degraded by the presence of intervening elements between the subject and the verb (Harada 1971), as shown in (4).

(4) a. Subject in the adjacent condition

Kyoo	*juku-de*	*kodomotachi-**ga/no***	*naratta*	*rekishi-wa*
today	cram.school-at	children-NOM/GEN	studied	history-TOP

"The history that the children studied at a cram school today . . ."

b. Subject in the non-adjacent condition

*Kodomotachi-**ga/no***	*kyoo*	*juku-de*	*naratta*	*rekishi-wa*
children-NOM/GEN	today	cram.school-at	studied	history-TOP

"The history that the children studied at a cram school today . . ."

2 In generative syntax studies, there is a dispute as to whether *ga*- and *no*-marked subjects share the same syntactic structure; this chapter probed the difference in frequency and the processing cost of reanalysis on the *no*-marked NP sentence, leaving it to future research to resolve the theoretical dispute.

From an empirical perspective, Nambu and Nakatani (2014) conducted an acceptability judgment experiment and confirmed that the acceptability of *no*-marked subjects was degraded in the non-adjacent condition, such as (4b), while *ga*-marked subjects were not sensitive to the adjacency factor. Irrespective of such a syntactic constraint, they revealed the main effect of the case-marking factor such that the acceptability of *no*-marked subjects was lower than that of *ga*-marked subjects. Moreover, Nambu (2013a) analyzed frequencies of occurrence of *ga*- and *no*-marked subjects in relevant linguistic environments in corpus data and identified the scarcity of *no*-marked subjects and the effect of the adjacency constraint (adjacent *ga*, 88.9%; non-adjacent *ga*, 99.8%; adjacent *no*, 11.1%; non-adjacent *no*, 0.2% in the Corpus of Spontaneous Japanese Speech).

The predominant use of *ga* as a subject marker in the relevant environments has stemmed from language change (Frellesvig 2010; Nambu 2019); further, the primary function of *no* is adnominal, typically possessive. From the perspective of comprehension, Nambu (2013b) conducted a sentence completion experiment, where participants were provided a *no*-marked NP and asked to complete the sentence. They found that the adnominal interpretation was dominant over the subject interpretation (adnominal interpretation, 83.2%; subject interpretation, 16.8%).

These empirical findings suggest that *no*-marked subjects, which are far less frequent than *ga*-marked ones, likely induce the adnominal interpretation and, thus, require a syntactic reanalysis during online comprehension. However, to the best of our knowledge, no previous studies have investigated whether brain regions associated with syntactic reanalysis were activated when reading sentences with *no*-marked subjects.

1.3 Aims of the study

We conducted two fMRI experiments to test two hypotheses separately. Experiment 1 tested the hypothesis that a *wa*-marked subject is located at a higher syntactic position than a *ga*-marked subject, thus increasing the neural costs for structure-building. Experiment 2 tested the hypothesis that a *no*-marked subject activates brain regions associated with syntactic reanalysis because a genitive subject is far less frequent than a nominative subject. Moreover, Experiment 2 examined whether reanalysis-related brain activation further increased when a genitive subject was non-adjacent to the verb.

2 Experiment 1: *wa*- vs. *ga*-marked subjects

The first experiment aimed to test the hypothesis that *wa* constructions introduce an additional syntactic hierarchy, increasing the neural cost relative to *ga* constructions. Previously, we demonstrated that the left pars opercularis (PO) in the IFG and the left posterior middle temporal gyrus (pMTG) were responsive to the level of syntactic hierarchy but not to the processing cost associated with the linear distance between the filler and the gap, comparing OSV- and SOV-order sentences (Iwabuchi, Nakajima, and Makuuchi 2019). Accordingly, we hypothesized that topicalized sentences induce higher activity in these regions than non-topicalized sentences. We performed hypothesis-driven volume of interest (VOI) analyses to test this hypothesis. Additionally, we conducted a whole-brain analysis to confirm that VOIs did not overlap with a larger activated cluster mainly covering other functional areas.

2.1 Methods

This chapter employed some of the data from our previous study; the details of the participants, the experimental stimuli, and the procedure have been reported (Iwabuchi, Nakajima, and Makuuchi 2019).

2.1.1 Participants

Twenty-two participants (mean 24.7 years old, 19–35 years old; nine male and 13 female) were recruited; three were excluded from the following analyses given the low probe-matching task accuracy (see Iwabuchi, Nakajima, and Makuuchi 2019 for details). All participants were right-handed (Flanders handedness questionnaire, score range 90–100; Nicholls et al. 2013) native Japanese speakers, had normal or corrected-to-normal vision, and had no history of neuropsychiatric disorders.

2.1.2 Stimuli

In our previous study, we initially created 30 SOV sentences with a heavy subject (hS; e.g., *Takabisya-na seikaku-no sakka-ga gaka-o nagutta.* ["The writer with an aloof character punched the painter."]) and 30 SOV sentences with a heavy object (hO; e.g., *Sakka-ga takabisya-na seikaku-no gaka-o nagutta.* ["The writer punched the painter with an aloof character."]) (see Iwabuchi, Nakajima, and Makuuchi 2019 for the complete list of the sentences). We then created the sentences with a topicalized subject, replacing the nominative marker *ga* with the topic marker *wa* in the SOV sentences. This study used these topicalized sentences as target stimuli to contrast *wa*-marked constructions with *ga*-marked ones. A 2 × 2 factorial design was employed, including the TOPICALIZATION (non-topicalized SOV, topicalized SOV [S_{TOP}OV]) and HEAVINESS (hO, hS) factors. Sentences (5a-d) represent examples of hO-SOV, hS-SOV, hO-S_{TOP}OV, and hS-S_{TOP}OV, respectively. We included the factor of HEAVINESS to confirm that the effect of TOPICALIZATION was not affected by the linear distance between nominal elements in a sentence. We also examined the effect of HEAVINESS on behaviors and brain activity, although this was not our primary area of interest.

(5) a. *Sakka-ga* *takabisya-na seikaku-no gaka-o* *nagutta*
[writer-NOM] [an aloof character-with painter-ACC] punched
"The writer punched the painter with an aloof character."
b. *Takabisya-na seikaku-no sakka-ga* *gaka-o* *nagutta*
[an aloof character-with writer-NOM] [painter -ACC] punched
"The writer with an aloof character punched the painter."
c. *Sakka-wa* *takabisya-na seikaku-no gaka-o* *nagutta*
[writer-TOP] [an aloof character-with painter-ACC] punched
"The writer punched the painter with an aloof character."
d. *Takabisya-na seikaku-no sakka-wa* *gaka-o* *nagutta*
[an aloof character-with writer-TOP] [painter -ACC] punched
"The writer with an aloof character punched the painter."

2.1.3 Procedure

The sentence stimuli were presented with the rapid serial visual presentation paradigm; the duration of each phrase was set at 700 ms. The Presentation software (Neurobehavioral Systems, Inc., Albany, CA, USA) was used to control the stimulus presentation. For each participant, the stimulus presentation order was pseudorandomized. After completing practice sessions (see Iwabuchi, Nakajima, and Makuuchi 2019 for details), participants underwent three fMRI runs. In each run, 10 sentence stimuli were presented for each condition (i.e., hO-SOV, hS-SOV, hO-S_{TOP}OV, hS-S_{TOP}OV). In 40% of the trials, participants performed a probe-matching task where they were required to judge the semantic matching between a target sentence (e.g., *Takabisya-na seikaku-no sakka-ga gaka-o nagutta.* ["The writer with an aloof character punched the painter."]) and a probe sentence (e.g., *Sakka-ga gaka-o nagutta.* ["The writer punched the painter."]). In the probe-matching task, semantically correct probes were presented on half of the trials, whereas, on the other half, incorrect probes were presented. We have described elsewhere how those probes were created (Iwabuchi, Nakajima, and Makuuchi 2019).

2.1.4 Functional magnetic resonance imaging data acquisition

A 3-T MRI scanner (MAGNETOM Skyra; Siemens, Erlangen, Germany) was used for MRI data collection. We acquired functional scans using the following parameters: repetition time (TR) = 2,000 ms, echo time (TE) = 30 ms, matrix 64 × 64, flip angle = 90 degrees, field of view = 192 × 192 mm, 35 axial slices, and slice thickness = 3 mm with 1 mm gap. We acquired 485 volumes during each fMRI run. For anatomical reference, a T1-weighted image was obtained from each participant: MPRAGE sequence, TR = 2,300 ms, TE = 2.98, inversion time = 900 ms, field of view = 256 × 256 mm, matrix 256 × 256, 224 sagittal slices, 1 mm isotropic voxel, flip angle = 9 degrees.

2.1.5 Behavioral data analysis

The accuracy and mean reaction time in the probe-matching task were measured and subjected to a two-way analysis of variance (ANOVA) with two within-subjects factors: TOPICALIZATION (topicalized, non-topicalized) and HEAVINESS (hO, hS).

2.1.6 Whole-brain functional magnetic resonance imaging analysis

Using the SPM12 software,[3] we initially conducted a whole-brain analysis for the same preprocessed functional dataset used in Iwabuchi, Nakajima, and Makuuchi (2019). After the condition effects were estimated using a conventional general linear model approach (see Iwabuchi, Nakajima, and Makuuchi 2019 for the detailed descriptions), the individual beta maps of the four experimental conditions (i.e., hO-SOV, hS-SOV, hO-S_{TOP}OV, and hS-S_{TOP}OV) were submitted to a full factorial ANOVA with two within-subjects factors of TOPICALIZATION and HEAVINESS. The main TOPICALIZATION effect was identified using a paired *t*-test to compare the brain activation for topicalized and non-topicalized sentences. The statistical maps were initially thresholded at $p < 0.001$ (uncorrected at the peak level). Statistical

3 Available at http://www.fil.ion.ucl.ac.uk/spm/

inferences were based on a threshold of $p < 0.05$ with family-wise error correction at the cluster level.

2.1.7 Volume-of-interest-based functional magnetic resonance imaging analysis

We performed an *a priori* VOI analysis for these regions in addition to the whole-brain analysis. Definitions of the VOIs in the left PO and left pMTG were provided by Iwabuchi, Nakajima, and Makuuchi (2019). From these predefined VOIs, we extracted the percent signal change during the sentence presentation period for each experimental condition and averaged it across three fMRI runs. We used the Marsbar toolbox (Brett et al. 2002) to obtain the percent signal changes. For each of the PO and pMTG VOIs, we submitted the calculated percent signal changes to a two-way ANOVA with the factors of TOPICALIZATION and HEAVINESS. We also performed a two-way ANOVA of the percent signal change data for each fMRI run. As described below, the experimental effect on brain activity may decrease as the fMRI runs progress (see Section 3.2). We conducted a post-hoc run-by-run analysis to examine whether such a trend was observed for the different types of experimental stimuli used in Experiment 1.

2.2 Results

2.2.1 Behavioral results

Mean reaction time and standard deviation (SD) were as follows: hO-SOV, 1547±50 ms; hS-SOV, 1570±56 ms; hO-S_{TOP}OV, 1622±64 ms; hS-S_{TOP}OV, 1581±64 ms. We found a significant main effect of TOPICALIZATION on reaction time ($F(1,18) = 4.83$, $p = 0.04$). The other effects or interactions were not statistically significant (HEAVINESS, $F[1,18] = 0.006$, $p = 0.94$; interaction, $F[1,18] = 0.68$, $p = 0.42$). The accuracy in each condition (mean±SD) was as follows: hO-SOV, 89.4±2.0%; hS-SOV, 92.9±1.5%; hO-S_{TOP}OV, 91.6±2.2%; hS-S_{TOP}OV, 88.7±2.0%. Regarding accuracy, no significant effect or interaction was observed (TOPICALIZATION, $F[1,18] = 1.25$, $p = 0.28$; HEAVINESS, $F[1,18] = 0.52$, $p = 0.48$; interaction, $F[1,18] = 1.87$, $p = 0.19$).

2.2.2 Functional magnetic resonance imaging results: Whole-brain analysis

The contrast of topicalized versus non-topicalized sentences revealed a large significant cluster from the supramarginal gyrus to the pMTG via the posterior superior temporal gyrus (pSTG) (peak coordinate, [-54 -55 26]; *t*-value, 4.49; cluster size, 46; Figure 1). We also identified a significant cluster in the precuneus (peak coordinate, [9, -64, 22]; *t*-value, 3.71; cluster size, 51). We found no significant activation for the reverse contrast (non-topicalized > topicalized). The effect of heaviness and the interaction also revealed no activation.

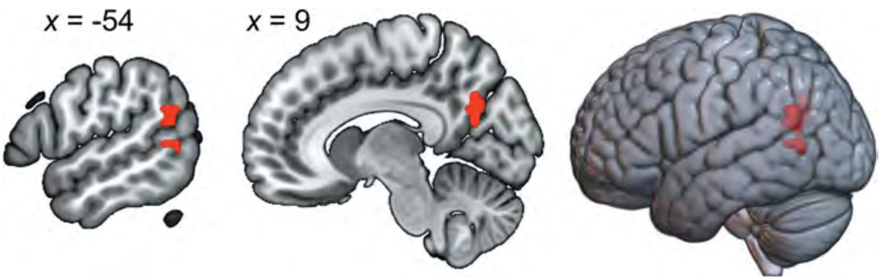

Figure 1: Result of the whole-brain analysis in Experiment 1. The numbers denote the x coordinates of the sagittal slices.

2.2.3 Functional magnetic resonance imaging results: Volume of interest analysis

We found a significant main effect of TOPICALIZATION for the left PO ($F[1,18] = 8.71$, $p = 0.0085$; the top left panel in Figure 2) and a marginally significant effect of it for the pMTG ($F[1,18] = 4.00$, $p = 0.061$; the bottom left panel in Figure 2). The main effect of HEAVINESS was also significant for the left PO (HEAVINESS, $F[1,18] = 5.12$, $p = 0.036$; interaction, $F[1,18] = 2.32$, $p = 0.14$), whereas neither the effect of HEAVINESS nor an interaction was significant for the left pMTG (HEAVINESS, $F[1,18] = 0.004$, $p = 0.95$; interaction, $F[1,18] = 0.47$, $p = 0.50$).

As in Figure 2 (the right panels), a run-by-run VOI analysis revealed that the main effects of TOPICALIZATION were significant or marginally significant only during the third run (PO, $F[1,18] = 16.92$, $p = 0.0007$; pMTG, $F[1,18] = 3.86$, $p = 0.065$) without any other reliable effects or interactions (*p*-values > 0.1). For both VOIs, we found no reliable effects or interactions during the first and second runs (*p*-values > 0.1).

2.3 Discussion

The finding that the left PO and pMTG showed increased activation for Japanese topicalized sentences relative to non-topicalized sentences supported the hypothesis that topicalization introduces additional neural costs in syntax-related sites by adding a syntactic layer. The slower response times for topicalized sentences than for non-topicalized ones also indicated that topicalization imposes an additional syntactic cost, corroborating the findings of Imamura, Sato, and Koizumi (2016).

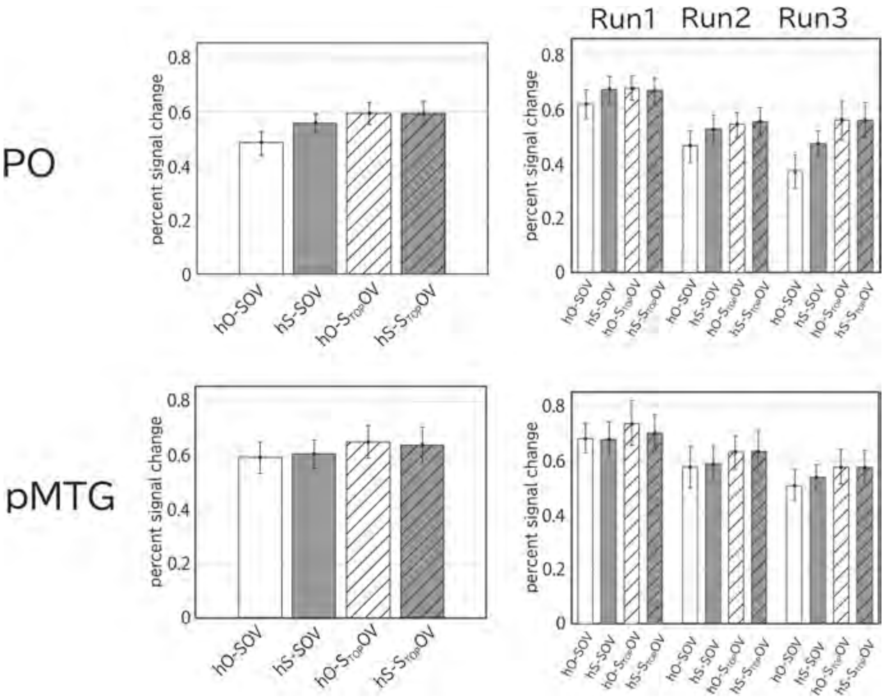

Figure 2: Results of the volume of interest analysis in Experiment 1. Left panels show the mean percent signal changes for each experimental condition in the left PO and pMTG. Right panels show the results from the run-by-run analysis. For the right panels, bars in each run (Runs 1, 2, and 3) represent hO-SOV, hS-SOV, hO-S_{TOP}OV, and hS-S_{TOP}OV from left to right. Error bars denote standard errors. PO, pars opercularis. pMTG, posterior middle temporal gyrus. hO-SOV, non-topicalized sentences with a heavy object. hS-SOV, non-topicalized sentences with a heavy subject. hO-S_{TOP}OV, topicalized sentences with a heavy object. hS-S_{TOP}OV, topicalized sentences with a heavy subject.

A significant effect of HEAVINESS was found in the left PO, indicating that the activity there was higher for the hS sentences than for the hO sentences. In this study, stimuli with a heavy subject had a "long-before-short" construction, whereas sentences with a heavy object had a "short-before-long" construction, as shown in (5). As preferred constructions are generally easier to process and can induce less activation in relevant brain regions than non-preferred ones, the increased neural cost for the hS construction seems inconsistent with prior findings of the "long-before-short" preference in Japanese (Yamashita and Chang 2001). Another possible explanation is that the effect of HEAVINESS in the left PO may reflect the relative frequencies of the hS and hO constructions. To examine the frequencies of SOV sentences with hS or hO, we conducted a preliminary corpus analysis using the Balanced Corpus of Contemporary Written Japanese, which contains approximately 100 million words. This analysis revealed that the number of S_{TOP}-hO-V (61 tokens) was about six times that of hS_{TOP}-O-V (10 tokens). However, for sentences with a *ga*-marked subject, we found that the difference was relatively small between the number of S-hO-V constructions (25 tokens) and that of hS-O-V constructions (35 tokens). While the difference in the left PO activity was relatively large between S-hO-V and hS-O-V constructions with a *ga*-marked subject, it was small between S_{TOP}-hO-V and hS_{TOP}-O-V. This activation pattern is inconsistent with the frequency account of the HEAVINESS effect because the difference between S_{TOP}-hO-V and hS_{TOP}-O-V should be larger if the left PO activity reflects the frequency.

We must be cautious in generalizing these findings because this study had some limitations. Importantly, the literature has shown that predicate types or the presence of contextual information can influence the interpretation of *wa* and *ga* (Kuno 1973); therefore, the relative difficulties of *wa*- and *ga*-marked subjects may vary in different experimental settings. For example, in sentences such as "*Taroo-wa yuushuu-da* [Taroo is brilliant]," *wa* is more typically used, while a *ga*-marked subject is more typical in sentences such as "*Taroo-ga yuushoo-sita* [Taroo won the cup]." This study used the latter types of sentences, and we cannot exclude the possibility that the observed effect of topicalization depended on the use of specific predicate types. Moreover, the relative processing costs of *wa* and *ga* may also be affected by information structure; for example, Japanese speakers prefer a given-new order to the reverse order (Kuno 1978; Nakagawa 2020). Future studies can disentangle the effects from the syntactic effect of topicalization.

3 Experiment 2

The differential processing cost of *ga* and *no* was examined with sentences with *ga*/*no* subjects, placed at an adjacent and a non-adjacent position relative to the verb in a 2 × 2 factorial design with factors PARTICLE (*ga*/*no*) and DISTANCE (adjacent [Adj]/non-adjacent [Non-adj]).

3.1 Methods

3.1.1 Participants

Twenty-two native Japanese speakers participated in the fMRI experiment. Data from four subjects were discarded because of low performances (the average of four runs was less than 75%). Thus, data from 18 subjects (11 females, aged 19–34 years, mean age 27.3 years) were analyzed. No participants had a history of neuropsychiatric disorders, and all had normal or corrected-to-normal vision. All were right-handed (mean score of Flanders handedness questionnaire 100; Nicholls et al. 2013) and gave their written informed consent.

3.1.2 Stimuli

The target stimuli of the experiment comprised the adjacency (DISTANCE, Adj vs. Non-adj) and the case-marking (PARTICLE, nominative *ga* vs. genitive *no*) factors in a 2 × 2 factorial design, yielding four experimental conditions. We used 30 lexical sets to create 120 target stimuli across the four conditions. As in (6), the Non-adj conditions contained two interveners: a temporal adverb and a locative postpositional phrase. The Adj conditions were constructed by scrambling the interveners of the Non-adj conditions to the front of the sentences.

(6) a. Nominative g*a*, Non-adj

Titi-ga	*sengetu*	*syuttyoosaki-de*	*nonda*	*osake-wa*
father-NOM	last.month	businesss.trip-at	drank	sake-TOP

yasumono-datta-sooda.
cheap.one-was-I.heard
"I heard sake that (my) father drank on his business trip last month was cheap."

b. Genitive *no*, Non-adj

Titi-no	*sengetu*	*syuttyoosaki-de*	*nonda*	*osake-wa*
father-GEN	last.month	businesss.trip-at	drank	sake-TOP

yasumono-datta-sooda.
cheap.one-was-I.heard
"I heard sake that (my) father drank on his business trip last month was cheap."

c. Nominative *ga*, Adj

sengetu	*syuttyoosaki-de*	*Titi-ga*	*nonda*	*osake-wa*
last.month	businesss.trip-at	father-NOM	drank	sake-TOP

yasumono-datta-sooda.
cheap.one-was-I.heard
"I heard sake that (my) father drank on his business trip last month was cheap."

d. Genitive *no*, Adj

sengetu	*syuttyoosaki-de*	*Titi-no*	*nonda*	*osake-wa*
last.month	businesss.trip-at	father-GEN	drank	sake-TOP

yasumono-datta-sooda.
cheap.one-was-I.heard
"I heard sake that (my) father drank on his business trip last month was cheap."

3.1.3 Procedure

We used a rapid serial visual presentation paradigm that was almost identical to Experiment 1, but the duration of each frame was 600 ms, resulting in a sentence duration of 4100 ms. The probes, created similarly to Experiment 1, followed 25% of the trials, and participants could not predict when they appeared. The probes motivated participants to read and understand every sentence.

3.1.4 Functional magnetic resonance imaging data acquisition

We collected MRI data using the same scanner used in Experiment 1. The difference was that we used a multiband-accelerated echo-planner imaging sequence in Experiment 2 (Moeller et al. 2010). The acquisition order was ascending, and the following parameters were used: TR = 1,000 ms, TE = 30 ms, flip angle = 68°, field of view = 192 × 192 mm^2, matrix 64 × 64, 30 axial slices, slice thickness = 3 mm with a 1 mm gap, and multiband acceleration factor = 2. Four fMRI runs were conducted with 720 volumes per run. T1-weighted high-resolution structural images were acquired with the same parameters as in Experiment 1.

3.1.5 Whole-brain functional magnetic resonance imaging analysis

We conducted preprocessing and whole-brain analyses using the same protocol as in Experiment 1, except that the factors of PARTICLE and DISTANCE were included in the full factorial ANOVA.

3.1.6 Volume-of-interest-based functional magnetic resonance imaging analysis

As in Experiment 1, we performed the VOI analyses using the Marsbar toolbox to detect the weak effect. We assumed that a *no*-marked NP was initially interpreted as a non-subject and reinterpreted as nominative when a verb appeared. Hirotani et al. (2011) investigated the neural correlates of thematic and syntactic reanalysis in Japanese passive and causative constructions and revealed the left pars triangularis (PT) in the IFG and the left pSTG for the loci of the effects. Using spherical VOIs with 6 mm diameter, we performed VOI analyses for each run using the relevant coordinates (Hirotani et al. 2011; Figure 3).

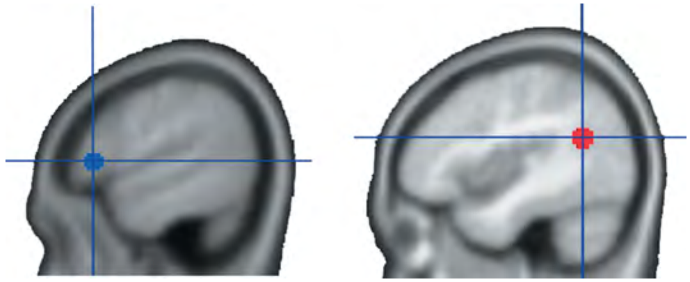

Figure 3: The left PT and pSTG VOIs for Experiment 2. Left, the left PT spheric VOI centered at [-54 27 6]. Right, the left pSTG spheric volume of interest centered at [-42 -57 21] with a 6 mm diameter. PT, pars triangularis; pSTG, posterior superior temporal gyrus.

3.2 Results

3.2.1 Behavioral results

Because the probes followed only 25% of the trials, we deemed the performance for each condition not reliable enough to make a statistical inference for the comparison of conditions. We used accuracy rates when selecting the participants for the fMRI data analysis and excluded four whose overall accuracy rates were <75%.

3.2.2 Functional magnetic resonance imaging results: Whole-brain analysis

The whole-brain analyses did not reveal any statistically significant activation.

3.2.3 Functional magnetic resonance imaging results: Volume of interest analysis

For data averaged across all runs, a two-way within-subjects ANOVA revealed a significant main effect of DISTANCE in the PT ($F[1,22] = 4.85$, $p = 0.038$), but the effect of PARTICLE ($F[1,22] = 0.05$, $p = 0.83$) and an interaction ($F[1,22] = 0.43$, $p = 0.51$) were not significant (Figure 4). We found no significant effect or interaction in the pSTG (p-values > 0.61). We then conducted a run-by-run post-hoc analysis. For the first run, we found significant main effects of PARTICLE ($F[1,22] = 8.77$, $p = 0.007$) and DISTANCE ($F[1,22] = 14.13$, $p = 0.001$) without an interaction ($F[1,22] = 0.17$, $p = 0.68$) in the PT, but no significant effects (p-values > 0.1) were detected except for the effect of DISTANCE in the pSTG ($F[1,22] = 7.15$, $p = 0.01$). For the succeeding runs, no reliable effect was revealed in either VOI (p-values > 0.09).

3.3 Discussion

Consistent with previous studies showing that *no*-marked subjects placed at a distance from the verb are the most highly loaded, the *no* Non-adj condition showed the highest activity in the VOIs, though, statistically, the PARTICLE x DISTANCE interaction was not significant, and only the main effect of the PARTICLE was significant exclusively in the first run. The brain activity reflected the relative frequency, which means that *ga*-marked subjects are produced far more often than *no*-marked ones, as revealed by the contrast “*no* > *ga*” only in the first run but not thereafter.

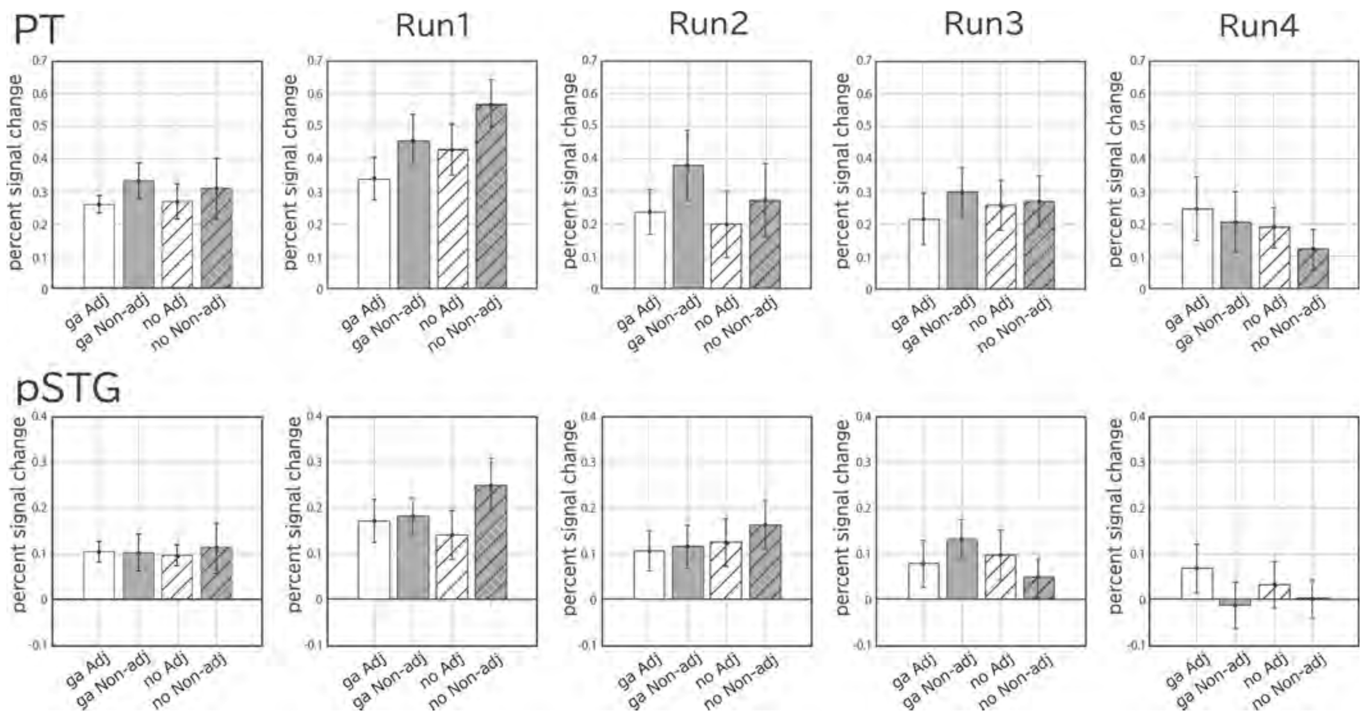

Figure 4: Results of the volume of interest analysis in the left PT (top panels) and pSTG (bottom panels). The leftmost panels show the mean percent signal changes, averaged across the four runs, for each condition. The right four columns show the results from the run-by-run analysis; the percent signal changes in each run are shown from left to right. Error bars denote standard errors. PT, pars triangularis. pSTG, posterior superior temporal gyrus. Adj, the adjacent conditions. Non-adj, the non-adjacent conditions.

Although participants were aware that *no*-marked NPs were the subject, habitual adnominal reading competed with it in the first run because of its low frequency.

4 General discussion

We examined the neural costs for processing Japanese subject-marking particles *wa*, *ga*, and *no*. Experiment 1 demonstrated that the left PO and pMTG, both of which are responsive to syntactic hierarchy, showed increased activity for Japanese topicalization, supporting the hypothesis that the $S_{TOP}OV$ construction has a more complex syntactic structure than the SOV construction. In Experiment 2, the activities in the left PT and pSTG, involved in syntactic reanalysis, were significantly higher for the *no* condition than for the *ga* condition, but the effect was found only in the first fMRI run.

Unlike Experiment 1, the run-by-run analysis in Experiment 2 revealed the effects of PARTICLE and DISTANCE only during the first run; the left PO and pMTG consistently showed higher activity for the topicalized sentences than for the non-topicalized sentences in Experiment 1. However, the differences did not reach statistical significance during the first and second runs, perhaps because of a lack of statistical power. Hence, future studies should investigate the cause of the changing patterns of activity across sessions.

This study provides the first evidence that distinct Japanese subject-marking particles (i.e., *wa*, *ga*, and *no*) drive neural systems associated with syntactic processing differently. The findings endorse further applications of fMRI toward less-studied languages that have similar subject-marking particles such as Uyghur (Asarina 2011).

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Chapter 10
Pragmatic atypicality of individuals with autism spectrum disorder: Preliminary results of a production study of sentence-final particles in Japanese

1 Introduction

Autism-spectrum disorder (ASD) is a neurodevelopmental disorder characterized by difficulties in social communication and interaction, and the presence of restricted and repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). The formal language skills (e.g., lexicon, the morphosyntactic or semantic level) of people with ASD differ across individuals, but they generally have impairments in pragmatics (especially in the use of language in social communication; American Psychiatric Association 2013; Asperger 1991; Eigsti et al. 2011; Kanner 1943; Landa 2000; Tager-Flusberg, Paul, and Lord 2005), such as conversational inference, indirect speech acts, deictic expressions, and irony (Dennis, Lazenby, and Lockyer 2001; Happe 1993, 1994; Kalandadze et al. 2018; Lee, Hobson, and Chiat 1994; Loveland et al. 1988). As most studies on these issues examine English speakers and other European languages, it is necessary to examine the issues faced by non-European language speakers to understand the full picture of the pragmatic problems of ASD.

The linguistic expression called sentence-final particles (SFPs) is a particularly pragmatic characteristic of East and Southeast Asian languages, including Japanese. SFPs are bound morphemes that occur at the end of a sentence (Cooke 1989; Kwok 1984; Law 2002; Yamada 1908: 680–684). As they have no referential meanings, SFPs do not affect the truth condition of a sentence (Davis 2011; McCready 2005, 2009), instead expressing the speaker's attitudes, moods, or feelings (Cook 1988, 1992;

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Endo 2012; Iwasaki and Yap 2015; Miyagawa 2022: 138–195). In Japanese, the SFPs *-ne* and *-yo* are those most frequently used in casual conversations (Maynard 1993: 183–220, 1997). It is often suggested that *-ne* represents the speaker's (S) attitudes such as confirmation, agreement, or cooperation with the addressee (A), and *-yo* represents S' attitudes such as notification, explanation, emphasis, or insistence (e.g., Cook 1988; McCready and Davis 2020; Miyagawa 2022: 138–195; Uyeno 1971).

Many Japanese linguistic scholars assume that typical usages of *-ne* and *-yo* depend on whether the speaker (S) and the addressee (A) know the propositional information of the utterance (e.g., Kamio 1994, 1997; Maynard 1993: 183–220; Muraki and Koizumi 1989).[1, 2, 3] When A knows the proposition of the utterance (hereafter, the AK condition), Japanese speakers typically end the utterance with *-ne*, and when A does not know it (hereafter, S exclusively knows: SeK condition), Japanese speakers typically end the utterance with *-yo*. For example, in the scene in Figure 1(a), A knows the information that *Eagles has now won the championship,* given that A and S are watching the game together on TV. In this AK condition, SFP *-ne* can express S' attitude of confirmation or sharing the emotion with A. Using *-yo* in the AK condition is supposed to be atypical (although grammatical) because *-yo* implies that S is explaining the information to A. However, in a similar scene under the SeK condition (Figure 1b), *-yo* would be typical because A, who is cooking in the kitchen and, thus, is not watching the game, does not know the information. By attaching *-yo* at the end of the utterance, S can show a willingness to notify A.

Some SFPs can appear in combination with others. The above *-yo* and *-ne* often co-occur in the order of *–yone,* but never in the order of *-neyo* (for an explanation, see Endo 2012, and Miyagawa 2022: 138–195 for the analysis of sentence structure of SFPs).[4] The combined *-yone* is more typically used in the AK rather than SeK condition (see Oshima 2014b for details of the contexts in which *-yone* are used), indicating S' attitudes of insistence, and, at the same time, seeking A's confirmation

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1 There are exceptions, given the ongoing debate over the functions and usage of SFPs (McCready 2009; McCready and Davis 2020; Oshima 2014a, 2014b; Takubo and Kinsui 1997). Nevertheless, this study focuses on how speakers with ASD used *-ne* and *-yo* in instances where their typical development (TD) counterparts used them. We then focused on when TD individuals typically used *-ne* and *-yo* and prepared the task with reference to traditional theoretical classifications.

2 It has been argued that *-yo* is also used in soliloquy situations (Hasegawa 2010).

3 The typical usage of the SFP in this study is for speakers of the Tokyo dialect. They vary considerably per dialect (Konishi 2020).

4 Some researchers argue that *-yone* is a single SFP rather than a combination of *-yo* and *-ne*, based on the analysis of the relationship between intonation and discourse function (e.g., Oshima 2014b). However, given that this study does not analyze the prosodic effect, we followed the major assumption that *-yone* is morphologically a combination of *-yo* and *-ne* (Cook 1988; Endo 2012; McCready 2009; Miyagawa 2022: 138–195; Takiura 2008; Takubo and Kinsui 1997).

or agreement (Cook 1988). Based on the assumption that *-yone* is a combination of *-yo* and *-ne*, this study considers a sentence with *-yone* as a sentence ending in *-ne*.

Despite its brevity (one mora), the important role of the SFP in verbal communication has been identified by various studies. SFPs are frequently used by Japanese speakers in casual conversations, approximately once every 2.5 phrase-final position (Maynard 1993: 183–220, 1997). However, they hardly appear in formal situations, such as court sessions or press reports (Cook 1988; Maynard 1993: 183–220). Further, several experimental studies show that native Japanese speakers spontaneously perceive attitudes expressed via SFPs (Matsui, Yamamoto, and McCagg 2006; Matsui et al. 2009). Some studies also argue that SFPs function as turn-taking operations (Tanaka 2000), facilitate conversations (Kajikawa, Amano, and Kondo 2004), or control interpersonal relations (Takiura 2008).

a) The addressee knows the proposition (AK).

b) The speaker exclusively knows the proposition (SeK).

Figure 1: Examples of typical usages of Japanese common SFPs. (a) The typical condition for *-ne* use, where the addressee knows (AK) the proposition. (b) The typical condition for *-yo* use, where the speaker exclusively knows (SeK) the proposition.
Note: NOM, nominal; SFP, sentence-final particle.

Prior studies suggest that individuals with ASD show atypicality in their use of SFPs, but there is not enough data to form a comprehensive picture of the situation. There have been clinical observations and reported data that native Japanese children with ASD seldom use SFPs, especially *-ne* and *-yo*, in casual conversations, unlike the frequent use by children with typical development (TD) (Satake and Kobayashi 1987; Watamaki 1997). However, these studies only observed one or a few participants. Other experimental studies show some aspects of the atypicality of SFP use in individuals with ASD. For example, native Cantonese speakers with ASD produced fewer variations in SFPs (Chan and To 2016) than those with TD and were insensitive to S' intention, as expressed by the given SFP (Li et al. 2013). Similarly, among native Japanese speakers, TD adults with high autistic traits (i.e., Autism-Spectrum Quotient scores, AQ scores) less flexibly understand S' attitudes from SFPs than those with low AQ (Kiyama et al. 2018; Kiyama et al. 2020).[5] The atypicality in the SFP prosodic aspect of individuals with ASD has also been suggested. TD native Japanese speakers with higher AQ utter shorter SFPs than those with lower AQ (Kiyama, Song, and Nasukawa 2021). However, it remains unclear whether the alleged atypicality of SFP production is a characteristic of native Japanese speakers with ASD.

This chapter compares tendencies in SFP choices of native Japanese-speaking adults with ASD with those of TD. As a preliminary study for a future large-scale investigation, we limited our focus to the most common SFPs: *-ne* and *-yo*. Here, we utilize an oral discourse completion task (ODCT), which presents participants with the contexts of the AK and SeK conditions and asks them to freely produce the sentence-final expressions that they find suitable in the given context. Nevertheless, individuals with ASD may have difficulty grasping AK/SeK implicitly presented through written and drawn materials, as previous psychological studies report their atypicality in inferring others' mental states from linguistic and physical contexts (Baron-Cohen 1995; Baron-Cohen, Leslie, and Frith 1985; Frith 2001; Senju et al. 2009). We explicitly present the knowledge of the hypothesized S and A in the ODCT and tested whether the participants correctly remembered this information to prevent possible undesirable failures.

We hypothesize that the choice of the SFPs *-ne* and *-yo* changes per the factors of Context (AK/SeK condition) and Group (ASD/TD participants). For Context, the *-ne* (*-yo*) production should be more frequent under the AK (SeK) than SeK (AK) condition. For Group, adults with ASD should produce *-ne* and *-yo* less frequently than TD adults. On the Context-Group interaction, the frequencies of *-ne* and *-yo* in

5 Autism-Spectrum Quotient (AQ) (Baron-Cohen et al. 2001) is a self-administered instrument for measuring the degree to which an adult with normal intelligence has the traits associated with ASD. AQ assumes the continuum from ASD to TD, with higher AQ scores indicating higher autistic traits.

the TD group should differ between the AK and SeK conditions, but this difference should not be observed for the ASD group.

2 Methods

2.1 Participants

Eleven adults with ASD (eight males, 20–48 years old, mean = 33.82, *SD* = 8.13) and 14 TD adults (eight males, 20–24 years old, mean = 21.86, *SD* = 1.35) participated in the ODCT. All participants were native Japanese speakers. We recruited ASD participants from Hasegawa Hospital in Tokyo based on a diagnosis using the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (American Psychiatric Association 2013). The TD participants were (under)graduate students at Tohoku University in Sendai City and reported no history of neuropsychiatric disorders. This study was approved by the ethics committees of the National Rehabilitation Center for Persons with Disabilities in Japan, Hasegawa Hospital, and Tohoku University in the Kawauchi South District. The present study was conducted in accordance with the Declaration of Helsinki, and all participants provided written informed consent.

2.2 Stimuli

In the ODCT, we created eight dialogs for each of the AK and SeK conditions (Table 1), which specified whether the hypothesized S and A knew the proposition. Participants were asked to produce any sentence-final expressions they would use in the given context. Each trial had four phases: context phase, preceding utterance phase, target utterance phase to allow participants to attach any sentence-final expression, and comprehension question phase. In the context phase, whether S and A in the target utterance knew the proposition or if only S knew it was described. Next, the utterance by the interlocutor was presented. In the target utterance phase that followed, the end of the sentence was left blank to be completed using a sentence-final expression. In the comprehension question phase, we asked about the context and knowledge status of S and A.

Throughout the task, each participant was asked to imagine acting as the hypothesized S, interacting with the same hypothesized A named "Suzuki" (a common Japanese family name), who was a long-time acquaintance of the same age and sex. We designed the ODCT using the same A and did not include multiple persons, given the suggestion that individuals with ASD have limited imagination

(Baron-Cohen et al. 2001) and the cognitive load of imagining many hypothetical situations may be too high for them. Similarly, A's age and sex were fixed because individuals with ASD have atypicality in reflecting interpersonal relationships in linguistic expressions (Zalla et al. 2014), but Japanese speakers select SFP depending on it (Kamio 1994).

2.3 Procedure

Participants were visually presented with the stimulus materials for all four phases of one trial, using a paper handout for ASD participants and a PC monitor via Zoom online meeting software (Zoom Video Communications, Inc., San Jose, CA) for TD participants. While they saw the stimuli, the experimenter read aloud the context and the preceding utterance phrases and asked them how they would utter the target utterance if they were in the situation. The participants were then instructed to read aloud the target utterance sentence by filling in the blanks using a sentence-final expression. They were given three oral comprehension questions to check whether the participant understood the context correctly. Participants were allowed to change their answers as many times as they wished during the trial but were not allowed to return to the previous trials. The researcher documented the final answers. The task was conducted face-to-face for ASD participants and online using Zoom for TD participants.

2.4 Data Analysis

We excluded trials in which participants made errors in any of the comprehension questions before statistical analysis, as we aimed to examine the production of SFP when the participants had correctly grasped the knowledge status of the S and A. We also excluded expressions other than the SFPs *-n*e and *-yo* from the following analysis.

We constructed logistic mixed-effects models with maximal random effect structures (Barr et al. 2013) that had Context (AK/SeK), Group (ASD/TD), and their interaction as the fixed effects on the production of *-ne* and *-yo*, respectively. We included the by-subject (by-item) random slope for Context (Group) with the by-subject (by-item) random intercept. We compared the most complicated model with the simpler model to determine whether random slope parameters improved model fit using the Chi-square log-likelihood test. If the difference was significant, we adopted the model with the larger log-likelihood ratio; otherwise, we adopted the simpler one. If a model did not converge, we simplified the random effects

Table 1: Examples of the stimulus dialogs (English translation).

Phase	**A knows the proposition (AK).**	**S exclusively knows the proposition (SeK).**
Context	"You and Suzuki are going to visit the famous museum. You often go there, so you **know** the museum is in the city. Suzuki has also been there sometimes, so he/she **also knows** the museum is in the city."	"You and Suzuki are going to visit the castle. You have visited there, so you **know** the castle is in the direction of the lake. Suzuki has not visited there, so he/she **does not know** where the castle is."
Preceding utterance	Suzuki: "I can't wait to go to the museum."	Suzuki: "I don't know where the castle is."
Target utterance	*Hakubutsukan-wa* *shigaichi-ni* *aru* ( ). museum-TOP city-in be ( ). You: "The museum is in the city – ( )"	*Oshiro-wa* *mizuumi-no* *hookoo-ni* *aru* ( ). castle-TOP lake-of direction-in be ( ). You: "The castle is in the direction of the lake – ( )"
Comprehension questions	(1) Where is the museum? (In the residential area/In the city) (2) Did you know where the museum is? (Yes/No) (3) Did Suzuki know where the museum is? (Yes/No)	(1) Where is the castle? (In the direction of the forest/In the direction of the lake) (2) Did you know where the castle is? (Yes/No) (3) Did Suzuki know where the castle is? (Yes/No)

Notes: A and S denote the addressee and the speaker, respectively.
TOP, topic.

structure (Jaeger 2009). When the interaction was significant, we used Bonferroni correction to perform post-hoc comparisons of Group (ASD/TD) by Context (AK/SeK). Statistical analysis was conducted using R version 3.6.1. (R Development Core Team 2018), using the lme4 package (Bates et al. 2014) for model estimation and emmeans (Lenth et al. 2020) for post-hoc comparison.

3 Results

Table 2 summarizes the accuracy of the comprehension questions. The ASD and TD groups understood the contents of the stimuli well. Figure 2 shows the proportion of SFPs produced by the participants in both groups, indicating that native Japanese speakers generally prefer *-yo* in SeK conditions. Meanwhile, they select various SFPs in the AK condition.[6] Moreover, individuals with TD used SFPs in almost all trials, while those with ASD produced utterances with no SFP more frequently than those with TD. In the following statistical analyses, we merged the production of *-yone* into *-ne*, as explained in the introduction.

Table 2: Mean (SD) of accuracy rates of comprehension questions.

		AK condition	SeK condition
Q1: (the content of the context)	ASD	93.18 (25.35)	98.86 (11.00)
	TD	98.21 (13.30)	100
Q2: (knowledge of S)	ASD	89.77 (30.47)	98.86 (10.10)
	TD	98.21 (13.30)	99.11 (9.45)
Q3: (knowledge of A)	ASD	94.32 (23.28)	98.86 (10.70)
	TD	99.11 (9.45)	100

Notes: A and S denote the addressee and the speaker, respectively.

6 Beyond *-yo* and *-ne* (*-yone*), the participants produced *-nokana*, *-kana*, *-no*, *-ka*, *-na*, *-ttesa*, *-tte*, *-kke*, *-kashira*, *-jan*, and *-janai*. These expressions were grouped together as one category (i.e., Other SFPs).

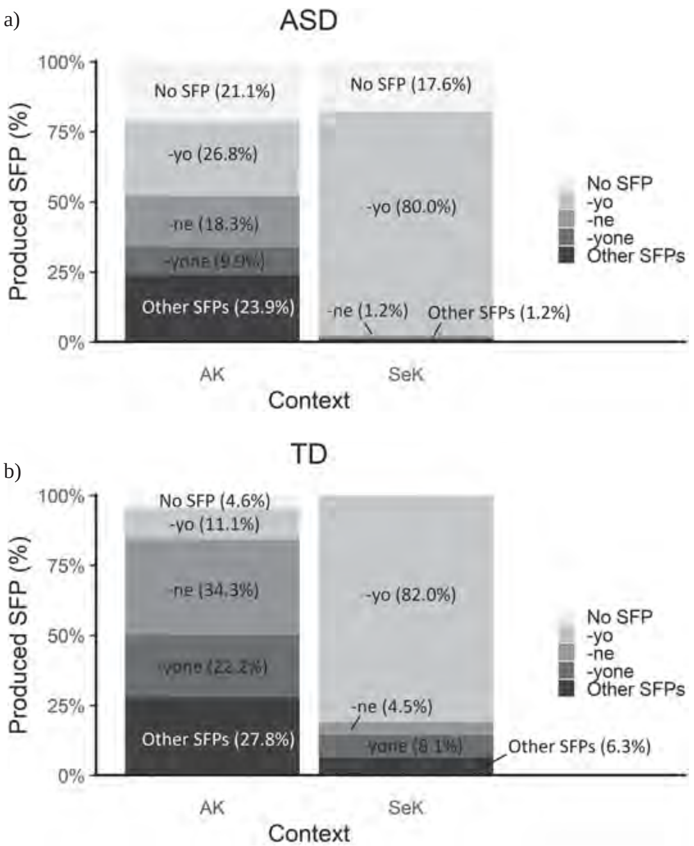

Figure 2: Proportion of Japanese sentence-final particles (SFPs) produced in each condition by a) adults with autism-spectrum disorder (ASD, *n* = 11) and b) those with typical development (TD, *n* = 14).

The logistic mixed-effects model analysis of utterances ending with *-ne* (Table 3) revealed significant main effects of Context (*estimate* = 2.608, *SE* = .624, *z* = 4.178, *p* < .001) and Group (*estimate* = −2.489, *SE* = 1.058, *z* = −2.352, *p* = .019) but no significant interaction between the two factors (*estimate* = 1.023, *SE* = 1.119, *z* = .914, *p* = .361). The results indicated that the frequency of *-ne* in the AK condition was significantly higher than in the SeK condition and that the ASD participants produced *-ne* less frequently than those with TD.

Table 3: Fixed effects of logistic mixed-effects model analysis on the production of utterances ending with *–ne.*

	estimate	SE	z	P
(Intercept)	−2.282	.481	−4.748	<.001
Context	2.608	.624	4.178	<.001
Group	−2.489	1.058	−2.352	.019
Context × Group	1.023	1.119	.914	.361

Notes: Final model = glmer(*-ne* ~ Context * Group + (1|Participant) + (1|Item), family = binominal).

As for *-yo*, the logistic mixed-effects model analysis (Table 4) indicated a significant main effect of Context (*estimate* = −4.662, *SE* = .620, $z = -7.514$, $p < .001$) and a significant interaction between Context and Group (*estimate* = 1.609, *SE* = .678, $z = 2.371$ $p = .018$), but the main effect of Group was not significant (*estimate* = −.102, *SE* = .664, $z = -.153$, $p = .878$). The frequency of *-yo* in SeK was significantly higher than that in AK. Given the post-hoc comparisons (Table 5), ASD participants used *-yo* significantly more frequently than those with TD in the AK condition (*estimate* = −1.507, *SE* = .695, $z = -2.168$, $p = .030$), whereas the difference in the SeK condition was not significant between the TD and ASD groups (*estimate* = .102, *SE* = .644, $z = .153$, $p = .878$).

Table 4: Fixed effects of logistic mixed-effects model analysis on the production of the utterance ending with *–yo.*

	estimate	SE	z	P
(Intercept)	1.934	.495	3.908	<.001
Context	−4.662	.620	−7.514	<.001
Group	−.102	.664	−.153	.878
Context × Group	1.609	.678	2.371	.018

Notes: Final model = glmer(*-yo* ~ Context * Group + (1|Participant) + (1|Item), family = binominal).

Table 5: Results of multiple comparisons of the production of the utterance ending with *–yo.*

	estimate	SE	z	P
AK/TD vs AK/ASD	−1.507	.695	−2.168	.030
SeK/TD vs SeK/ASD	.102	.644	.153	.878

4 Discussion

This study found differences in the use of the Japanese SFPs *-ne* and *-yo* under the application of the ODCT between native Japanese speakers with ASD and TD. It confirmed the patterns reported in previous case studies (Satake and Kobayashi 1987; Watamaki 1997) and revealed additional details. Adult participants with ASD produced SFPs less often than those with TD under AK and SeK conditions, especially *-ne*. This tendency accords with previous studies reporting the lack of use of SFPs, especially *–ne,* in conversations by children with ASD (Satake and Kobayashi 1987; Watamaki 1997). In contrast, adults with ASD overused *-yo* in the AK conditions, and their TD counterparts preferred *-ne*. Evidently, this overuse of *-yo* has not been reported in previous studies. The ASD and TD groups, however, produced more *-ne* in the AK than SeK condition and more *-yo* in the SeK than AK condition. Thus, adult native Japanese speakers with ASD acquire the use of the SFPs *-ne* and *-yo* per the context to some extent, unlike children with ASD, who seldom used SFPs (Satake and Kobayashi 1987; Watamaki 1997).

The design of ODCT allowed for interpreting differential patterns of SFP use between people with ASD and TD. The patterns observed in this study reflect their preferences in social language use unobscured by the challenges of people with ASD in inferring others' knowledge. Prior studies suggest that people with ASD have atypicality in understanding others' mental states, which are implicitly presented in context (Baron-Cohen 1995; Baron-Cohen, Leslie, and Frith 1985; Frith 2001; Senju et al. 2009). To avoid this possible confounding factor, the ODCT was designed to ensure that explicit information was provided about the knowledge of characters in the context phase. Additionally, the study utilized comprehension questions of the knowledge status of the characters, by which erroneous trials were excluded from the analysis. Hence, the differential patterns of SFP use between ASD and TD should not be attributed to the failure to understand context information by ASD.

Assuming ASD and TD groups have the same understanding of the given contexts, groups should have different strategies for reflecting the contextual information in linguistic expressions. First, individuals with ASD may have different lexical or structural representations of SFPs than those with TD. The overall frequency of *-yo* did not differ between the two groups, but individuals with ASD used *-ne* less frequently than those with TD. It corresponds to a previous report that an ASD child who does not use SFPs naturally can learn to use *-ne* and *-yo* through training, and that they preserve the usage of *-yo* but decline that of *-ne* in natural conversations (Matsuoka, Sawamura, and Kobayashi 1997). As in Miyagawa (2022: 138–195) based on Matsuoka, Sawamura, and Kobayashi (1997), individuals with ASD may have similar knowledge of *-yo* as those with TD, but atypical knowledge of *-ne* (see

Endo in press and Miyagawa 2022: 138–195 for a detailed analysis of the differences in the syntactic representation of *-yo* and *-ne* between ASD and TD). Second, individuals with ASD may have a biased knowledge of using language per context. Focusing on context, the atypical usages of *-ne* and *-yo* by the ASD group were found in the AK condition. In this condition where the addressee knows the proposition, those with ASD used *-ne* and *-yo* to almost the same degree, while their TD counterparts preferred *-ne* to *-yo*. Consistent with some studies indicating that individuals with ASD tend to take an egocentric context or perspective in pragmatic language processing (Deliens et al. 2018; Kissine 2012), the native Japanese-speaking participants with ASD in this study may have established knowledge of language use in an egocentric context (SeK condition) but have limited knowledge in a context where A's perspective must be considered (AK condition). It may induce a high cognitive load for SFP choices in the AK condition, thereby resulting in poorly controlled SFP use. Third, individuals with ASD may have different goals from their TD counterparts in social communication. Given the attitudes each SFP is supposed to express, the less-frequent use of *-ne* in the ASD group may have a lower intention to share a proposition with others than the TD group.[7] As for *-yo* in the AK condition, those with ASD may be more inclined to emphasize S' knowledge of the proposition to A than those with TD, regardless of whether A already knows. Such inappropriate use of self-insisting *-yo* may induce an undesirable impression that those with ASD ignore or do not consider the mental states of others. These distinctive attitudes by individuals with ASD may be related to the atypicality of social communication and interaction.

This study has four limitations that future studies must probe. The first is the small number of participants. The study had 14 TD participants and 11 ASD participants. Future studies must recruit more participants with stricter control of participants' attributes to draw clearer conclusions, as we did not thoroughly control for age, intelligence, education experience, and types and degree of the symptoms of ASD or other related impairments. Though some studies suggest subgroups of language impairments within ASD (Kjelgaard and Tager-Flusberg 2001), this study did not consider the variations in SFP usage among the ASD group. Therefore, as the next step, future studies must examine how individuals are differentiated in SFP usage within the ASD population. Second, this investigation of Japanese SFP usage focused on *-ne* and *-yo*, but there are many other SFPs in Japanese.[6] Notably,

7 A training study for a Japanese child (Matsuoka, Sawamura, and Kobayashi 1997) reported that the accuracy of *-ne* is retained over a long period, but the frequency of *-ne* in daily conversations decays rapidly. It cannot be concluded whether this *-ne* use stems from atypicality in knowledge of SFP, communicative intention, or both.

the right periphery of the Japanese clause allows speakers to utter various types of elements, including other types of SFPs and modal particles to express the speaker's intentions and attitudes toward the sentence (Uyeno 1971). Thus, further research must encompass other sentence-final expressions to elucidate the pragmatic atypicality in native Japanese speakers with ASD. Third, there is a lack of analysis of the prosody of ASD speech when using SFPs. Individuals with ASD have prosodic problems in production and comprehension (Shriberg et al. 2001), unlike TD speakers who change the functions of the SFP per prosody (Oshima 2014a, 2014b). Lastly, the mechanisms underlying such individual differences in SFP use must be probed. Many studies suggest that pragmatic problems in individuals with ASD regard their atypicality of cognitive traits, such as joint attention (Charman et al. 2003), perspective taking (Loveland 1984), theory of mind (Baron-Cohen et al. 1988), and empathy (Watamaki 1997). Regarding the atypical use of SFP in individuals with ASD, several hypotheses hinge on the relation between linguistic representations and cognitive characteristics (Endo in press; Miyagawa 2022: 138–195; Watamaki 1997). It is necessary to consider their cognitive characteristics to clarify how the atypicality of neurodevelopment in ASD relates to atypical SFP usage in verbal communication, and ultimately the pragmatic atypicality of ASD in general.

5 Conclusion

The present preliminary study attempted to differentiate the uses of Japanese SFPs -*ne* and -*yo* between native adult speakers with ASD, and those with TD by an ODCT. Adults with ASD used SFPs -*ne* and -*yo* in a typical manner to a certain degree, but the frequency of their use of SFPs was different from that of those with TD. Relative to TD speakers, ASD speakers less frequently produced -*ne*, which is typically used to share a proposition with another, and they excessively produced -*yo*—which typically shows the speaker's insistence—in contexts where this was considered inappropriate. To the best of our knowledge, this study was the first to analyze atypical uses of SFPs in adults with ASD through statistical group comparisons. The current preliminary study shows that the prospects for future large-scale investigations are promising.

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Chapter 11 Auditory comprehension of Japanese scrambled sentences by patients with aphasia: An ERP study

1 Introduction

Aphasia is an acquired neurogenic language disorder resulting from brain injury that typically affects the language areas in the left hemisphere. The most common types of aphasia are Broca's aphasia (BA) and Wernicke's aphasia (WA), diagnosed based on their performance in verbal production and comprehension, with reference to brain lesions individuals with these types of aphasia experience. BA is a non-fluent aphasia type, where patients have mild or moderate difficulty understanding complex grammar and severe impairments in speech production. BA patients (BAP) typically suffer damage in the anterior portion of the left hemisphere, including the left inferior frontal gyrus (IFG) known as the Broca's area (Dronkers et al. 2007). WA is a type of fluent aphasia, where patients experience poor verbal comprehension and fluently utter meaningless speech. The damage of WA patients (WAP) is typically in the posterior position of the left hemisphere (Goodglass and Kaplan 1972; Yamadori 1985), including the left posterior superior temporal gyrus (pSTG), known as Wernicke's area (Binder 2015). Nevertheless, WAP's lesions are not necessarily limited to those regions. Recently, a dual-stream model for auditory language processing has been supported. The dorsal pathway from the STG to the premotor cortex via the arcuate and superior longitudinal fascicle subserves specifically for sensory-motor mapping of sound to articulation,

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whereas the ventral pathway connecting the middle temporal gyrus (MTG) and ventrolateral prefrontal cortex (vlPFC) via the extreme capsule is responsible for auditory comprehension (e.g., Hickok and Poeppel 2007; Saur et al. 2008). Thus, BAP and WAP, suffering anywhere in these pathways, should have difficulty processing syntactically complicated sentences to a certain degree, regardless of the extent to which their speech performances seem fluent.

The complexity of syntactic processing increases per word order changes if languages have flexible word orders. The Japanese language is assumed to have the canonical sentence (CS) ordered subject (S), object (O), and verb (V), while allowing another scrambled sentence (SS) ordered OSV (Shibata et al. 2006). From Figure 1, relative to CS, SS has the initial O as a filler and the original position of the O in CS as a gap. When processing the Japanese SS, native speakers cannot specify the sentence as SS only by the initial O presentation because the given sentence may be a null-subject sentence (i.e., OV). They can specify SS after they are presented with an S, instead of a verb phrase (VP), following an O. During this time, they are required to use greater working memory to retain the O as a filler until the original gap position. This theoretical assumption has been supported by previous psycho- or neurolinguistic studies of Japanese sentence processing, reporting that SS induces a higher processing load than CS (e.g., Hagiwara et al. 2007; Koizumi et al. 2014; Tamaoka et al. 2005).

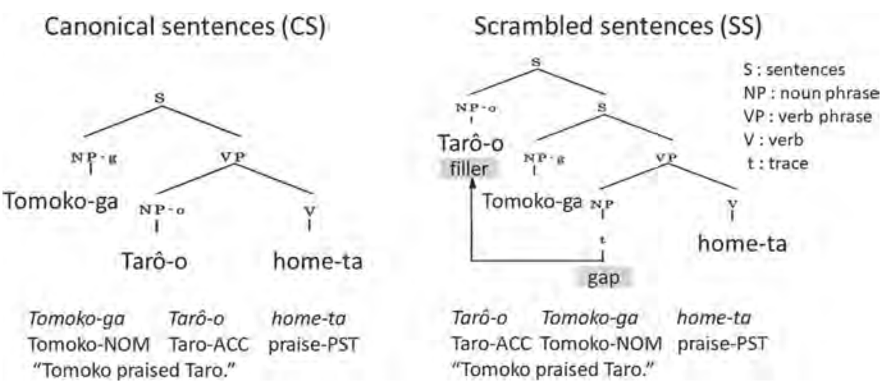

Figure 1: Syntactic structures of Japanese canonical and scrambled ordered sentences (Adapted from Shibata et al. 2006 with permission). S = sentence; NP = noun phrase; VP = verb phrase; V = verb; t = trace; NOM = nominative; ACC = accusative; PST = past.

The time course of the neural basis for processing disadvantage in Japanese SS has been attested in healthy young adult native speakers, utilizing event-related potentials (ERP) from electroencephalography (EEG). Reportedly, SS elicited greater positivity than CS approximately 600 ms after onset (i.e., P600 effect) and greater sustained left anterior negativity (Ueno and Kluender 2003; Wolff et al. 2008; Yano and Koizumi 2018; Yasunaga et al. 2015). Yano and Koizumi (2018) report that a P600 effect occurred at the presentation of the second noun phrase (NP), where the gap position appears in SS. Wolff et al. (2008) find that Japanese SS elicited a broadly distributed positivity after about 200–350 ms after the case marker of the second NP was auditorily presented.

The processing of SS is influenced by the semantic roles of NPs, in addition to the syntactic complexity. It is especially prominent when the roles of NPs are semantically reversible, such as when NPs are animate, allowing them to be interpreted as either the agent or patient of V (Richardson, Thomas, and Price 2010). Psycholinguistic studies show that semantically reversible sentences induce a particularly higher processing load for SS than CS than non-reversible sentences (e.g., one NP is animate and the other is inanimate). The effect of ambiguity of semantic roles for processing SS has been demonstrated in accusative (e.g., Ide, Terao, and Kiyama 2021 for Japanese) and ergative (e.g., Kiyama et al. 2013 for Kaqchikel Maya; Emura 2023 for Central Yupik) languages; it is supported by the fact that the syntactic analysis of case marking patterns requires a higher processing load when multiple NPs are semantically ambiguous.

Regarding sentence processing in patients with aphasia, Wassenaar and Hagoort (2005) report that their native Dutch-speaking BAP revealed a P600-like component for violating word categories in sentences, but the effect was reduced and delayed relative to their healthy counterparts. An earlier behavioral study suggests that Japanese-speaking patients with aphasia understand CS easier than SS (Hagiwara and Caplan 1990). However, the extent to which native Japanese-speaking patients with aphasia have severe problems in processing the SS in semantically reversible sentences is unknown in ERP.

From functional magnetic resonance imaging (fMRI) findings, there is some evidence of the neural basis for Japanese and other language's sentence processing that reveals stronger activation in the left IFG, including Broca's area for processing SS (Kinno et al. 2008; Koizumi and Kim 2016; Pallier, Devauchelle, and Dehaene 2011). A lesion study (Kinno et al. 2009) of glioma patients supports the assumption that the ventral pathway connecting the pSTG, MTG, and IFG in the left hemisphere is crucial to processing the SS. However, it remains an open question as to how patients with aphasia have difficulty with SS per the aphasia type in any language. This chapter is the first study to conduct an ERP experiment to compare how native Japanese BAP and WAP process semantically reversible CS and SS. It develops an effective training method of syntactic processing for Japanese patients with aphasia, especially for those who can understand sentences with simple structures but have difficulty understanding sentences with complicated structures that require an accurate analysis of case particles.

We hypothesized that BAP and WAP have special difficulty understanding semantically reversible SS, which causes a reduced and delayed P600 effect for SS relative to the healthy controls (HC). Regarding the difference between BAP and WAP, we could not propose any specific hypotheses given the lack of previous experimental studies. We expected that there were some differences between BAP and WAP but did not have a specific prediction about how they differ. Unlike most of the above-mentioned ERP and fMRI studies, we conducted an ERP experiment for processing SS in aphasia through auditory modality because most native Japanese-speaking patients with aphasia typically rely on spoken rather than written communication in their daily lives. It is urgent to reveal how these patients hear when processing the CS and SS rather than how they read them to utilize the expected neurolinguistic findings to develop the efficient rehabilitation of aphasia.

2 Methods

2.1 Participants

Three BAP (one woman, mean age = 54.30 years, *SD* = 3.09, range: 50–57 years), six WAP (one woman, mean age = 53.30 years, *SD* = 9.53, range = 35–63 years), and 18 age-matched adults as HC (10 women, mean age = 55.28 years, *SD* = 7.26, range = 39–66 years) participated in this experiment. The participants' native language was Japanese. All participants had normal hearing and normal or corrected-to-normal vision without signs of hemianopia or spatial neglect. They were right-handed or premorbidly right-handed according to a questionnaire based on the Japanese version of the Edinburgh Handedness Inventory (Oldfield 1971). All participants were assessed as being at a typical level of fluid intelligence per the Japanese standardized version of the Raven's Colored Progressive Matrices (RCPM, Maximum score = 36, Raven 1962; Sugishita and Yamazaki 1992, see Tables 1 and 2). From Figure 2, the aphasia patients' lesions were caused by any type of cerebrovascular accident that spread throughout the left hemisphere of the cortex. BAPs' lesions were spread in the frontal areas, whereas WAPs' lesions were generally extended to the temporal area from the frontal area. This study was approved by the Institutional Review Board of Tohoku University at South Kawauchi Campus, Miyagi, Japan, and the Ethics Committee of General Rehabilitation Mihono Hospital, Aomori, Japan. All participants provided written informed consent before the experiment, which was conducted per the Declaration of Helsinki, and received compensation for their participation.

Table 1: Demographic data of participants with aphasia.

	BAP, *n* = 3	**WAP, *n* = 6**	**HC, *n* = 18**
Mean age (years)	54.33 (3.09)	53.33 (9.53)	55.28 (7.26)
Sex ratio (women: men)	1: 2	1: 5	10: 8
Education (years)	13.50 (1.78)	11.50 (1.12)	14.83 (2.36)
RCPM	34.33 (1.70)	33.00 (1.91)	32.94 (2.90)

Notes: Standard deviations are shown in parentheses. BAP = Broca's aphasia patients; WAP = Wernicke's aphasia patients; HC = healthy controls; RCPM = Raven's Colored Progressive Matrices (maximum score = 36).

Table 2: Clinical characteristics of participants with aphasia.

Participant	**Age/Sex**	**Type of CVA**	**Lesion site**	**STA**	**WAB. II**
BAP1	57/M	ICH	L. putamen	II	9.1
BAP2	56/M	SAH	L. frontal lobe	II	8.75
BAP3	50/W	CI	L. insula.L. posterior frontal lobe	IV	9.45
WAP1	63/M	CI	L. temporal lobe . L. putamen	IV	9.6
WAP2	59/M	ICH	L. putamen	IV	9.6
WAP3	58/M	CI	L. deep cerebral white matter	II	8.5
WAP4	47/W	SAH	L. temporal lobe	II	8.1
WAP5	58/M	ICH	L. putamen	III	9.05
WAP6	35/M	ICH	L. putamen	III	9.6

Notes: BAP = Broca's aphasia patients; WAP = Wernicke's aphasia patients; M = man; W = woman; CVA = cerebrovascular accident, ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage; CI = cerebral infarction; L = left; STA = Syntactic Processing Test of Aphasia: Revised, whose level II refers to an understandable level of auditory comprehension of canonical sentences, III or IV refer to understandable levels for comprehending scrambled sentences. WAB.II = Auditory verbal comprehension in Western Aphasia Battery (maximum score = 10).

2.2 Stimuli

We created 48 Japanese transitive sentences, all of which were semantically reversible sentences, including an animate S (agent) and O (patient), as exemplified in (1). In each stimulus sentence, we used Japanese common given names with three morae for the NPs and a transitive V with three to five morae in the past tense. The gender of the name is always different between S and O in a sentence. For participants to process the sentences more naturally, a modal auxiliary *"rasî"* (meaning "seemingly") was followed by the VP, and a temporal adverb phrase (AdvP) was

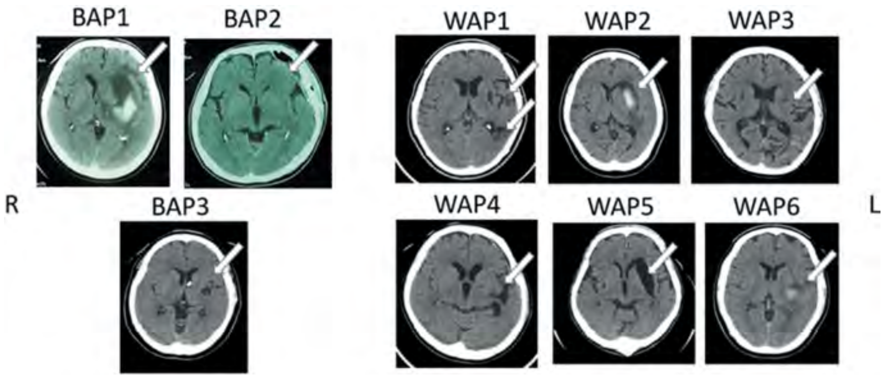

Figure 2: Lesions of BAP and WAP, imaged by computed tomography or magnetic resonance imaging. BAP = Broca's aphasia patient; WAP = Wernicke's aphasia patient; R = right; L = left.

inserted between S and O. Further, we prepared questions to check whether the participants correctly comprehended the content of each stimulus sentence. Each comprehension question concerned the content of any of the two NPs, VP, or AdvP such that participants paid proper attention to every phrase of the stimulus sentences. Given participants' reduced verbal working memory, the comprehension questions were prepared to be shorter sentences as much as possible.

The stimulus sentences were recorded phrase by phrase by a female native standard Japanese speaker who had a long career as a speech-language-hearing therapist; the sentences were recorded at a slow speed for the typical adult native speakers. The comprehension questions were recorded by a native male Japanese speaker. The duration of each NP was trimmed to 980 ms using Praat (version 6.0.43, Boersma and Weenink 2018) and Audacity (version 2.2.2, Free, open-source, cross-platform audio software). Moreover, the mean pitch between S and O was not significant (t = 1.092, p = 0.278, d = 0.111, 95%CI [-1.237, 4.260]). All stimulus sentences and comprehension questions are presented in Appendices A and B.

(1) Stimulus sentence[1]

a. CS (the word order of SOV)

Tomoko	ga	sensyû	no	nitiyôbi	Tarô	o	home
Tomoko	NOM	last week	GEN	Sunday	Taro	ACC	praise
ta	rasî						
PST	seemingly						

"It seems that Tomoko praised Taro last Sunday."

1 NOM [nominative], ACC [accusative], GEN [genitive], PST [past].

b. SS (the word order of OSV)

Tarô	o	sensyû	no	nitiyôbi	Tomoko	ga	home
Taro	ACC	last week	GEN	Sunday	Tomoko	NOM	praise
ta	rasî						
PST	seemingly						

"It seems that Tomoko praised Taro last Sunday."

2.3 Procedure

Participants sat in front of a computer screen (27" I-O DATA LCD-MQ271XDB monitor, Kanazawa, Japan) and underwent an EEG recording while they listened to the 48 stimuli with either CS or SS via a loudspeaker (Bose, Companion 2 computer speakers, Framingham, USA).In each trial, as in Figure 3, they were first visually presented with a fixation jittered between 3000 and 7000 ms, and a 2–1 countdown (1000 ms for each) followed by a fixation presented for 500 ms. Next, they were auditorily presented with the stimulus sentence while the fixation remained on the screen. Then, 1000 ms after the sentence presentation, they were auditorily presented with the comprehension question, to which they were subsequently asked to respond by pressing the "Yes" or "No" button (Cedrus, RB Series Response Pads RB-540, San Pedro, USA). The ERP trigger was set at the onset of the second NP (i.e., the O in the CS and S in SS). In each NP, taking 980 ms on average, a case marker *-ga*

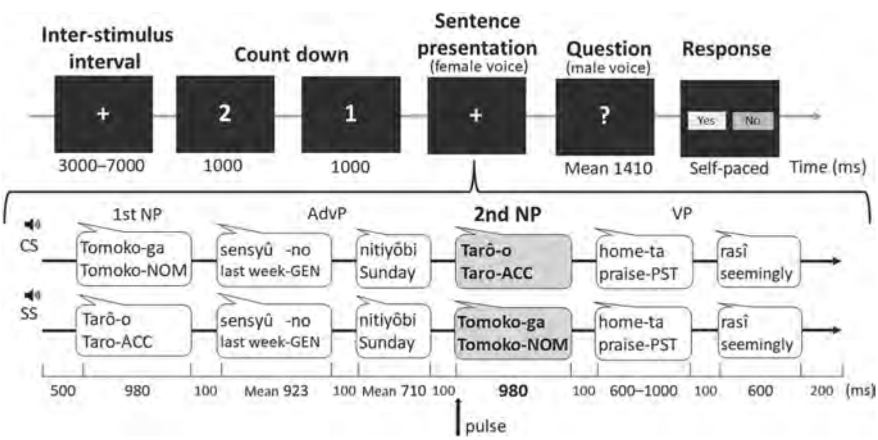

Figure 3: Experimental procedure. CS = canonical sentences; SS = scrambled sentences; NP = noun phrase; AdvP = adverb phrase; VP = verb phrase; NOM = nominative; ACC = accusative; GEN = genitive; PST = past.

(NOM) or *-o* (ACC), which notifies the grammatical role of the NP, was presented at approximately 700 ms after the onset of the second NP presentation. The participants underwent seven practice trials before the experiment. During the practice time, we adjusted for enough volume to listen to the stimuli. The procedure took approximately 40 minutes, excluding the electrode preparation. Participants took a short break every eight minutes. Python ver. 2.7.3 was used to present stimuli and obtain behavioral data.

2.4 Electroencephalographic data acquisition, preprocessing, and analysis

The EEG was recorded from NuAmps (A COMPUMEDICS NeuroScan, Texas, USA) using 29 Ag/AgCl electrodes mounted in an elastic cap (EasyCap, Munich, Germany) per the 10/20 system (Jasper 1958). Two additional electrodes were attached to the upper orbital ridge and external canthi of the left eye to monitor eye movements and blink artifacts. The online reference was set to the average of all electrodes, and the EEGs were re-referenced offline to the average value of the earlobes. The impedances of most electrodes were kept below 10 kΩ. Amplified analog voltages were digitized at 1000 Hz with a system bandpass filter between zero and 200 Hz.

The data preprocessing was processed offline using EEGLAB (Delorme and Makeig 2004) in MATLAB (8.6.0. 267246 [R2015b]) in the following procedures. First, the EEG data were down-sampled to 250 Hz and high pass-filtered with a cutoff of one Hz. Then, the power line noise was removed from the data using the Clean-Line plugin of EEGLAB. Artifact subspace reconstruction was performed to remove high-amplitude artifacts (Mullen et al. 2015). Next, bad channels were interpolated, and data were re-referenced to a common average reference. The adaptive mixture independent component analysis (Palmer et al. 2007) was performed for continuous EEG data to eliminate remaining periodical artifacts. Segmentation was selected from −700 to 1600 ms around the triggers. Furthermore, independent components with less than a 70% chance of being derived from brain activity and an estimated residual of more than 15% were removed by the IC label. The group analysis was conducted using the Monte Carlo permutation test (significance level 5 %) with cluster correction. We analyzed the ERPs focusing on the second NP. All trials were analyzed regardless of whether the questions were correct. The baseline was set to onset the posterior 100 ms of the second NP. We analyzed each group of BAP, WAP, and HC separately.

3 Results

3.1 Behavioral data

From Table 3, HC showed good performance in the comprehension task, with a mean accuracy of 94.33% (*SD* = 5.23) in CS and 90.97% (*SD* = 6.59) in SS. However, BAP and WAP showed lower performances than HC, as the mean accuracies were 74.30% (*SD* = 7.08) for CS and 69.45% (*SD* = 8.73) for SS regarding BAP and 74.35% (*SD* = 20.32) for CS and 74.65% (*SD* = 11.87) for SS regarding WAP. Apparently, BAP had difficulty comprehending SS, although the differences were not statistically comparable given the biased number of participants across the groups. As the content comprehension task aimed to let the participants pay proper attention to the stimulus sentence, the erroneous trials were not excluded from the subsequent EEG analysis.

Table 3: Mean accuracy rate of comprehension questions (%).

	BAP, n = 3	WAP, n = 6	HC, n = 18
CS	74.30 (7.08)	74.35 (20.32)	94.33 (5.23)
SS	69.45 (8.73)	74.65 (11.87)	90.97 (6.59)

Notes: Standard deviations are shown in parentheses. CS = canonical sentences; SS = scrambled sentences; BAP = Broca's aphasia patients; WAP = Wernicke's aphasia patients; HC = healthy controls.

3.2 Electrophysiological data

Figure 4 shows the ERP results of the HC, BAP, and WAP processing of the second NP of CS and SS. In HC (Figure 4A), a significant difference was observed in the 900–950 ms time window after the onset of the second NP, indicating a larger positivity for SS than CS on the bilateral frontal, temporal, parietal, and occipital regions (FC5, T7, F3, FC1, C3, CP1, Fz, FCz, Cz, Pz, F4, FC2, C4, CP2, P4, O2, F8, FC6, T8, and CP6). Regarding BAP (Figure 4B), similar to HC, a significant difference between CS and SS was observed in the 900–950 ms time window after the onset of the second NP. BAP showed HC-like positivity for SS in the bilateral frontal and parietal regions (F3, FC1, Fz, FCz, Cz, F4, and FC2.), but the number of significant electrodes was lower than that of HC. WAP revealed no significant differences in any electrodes, unlike HC and BAP. They did not induce any deflection in any time window between CS and SS (Figure 4C).

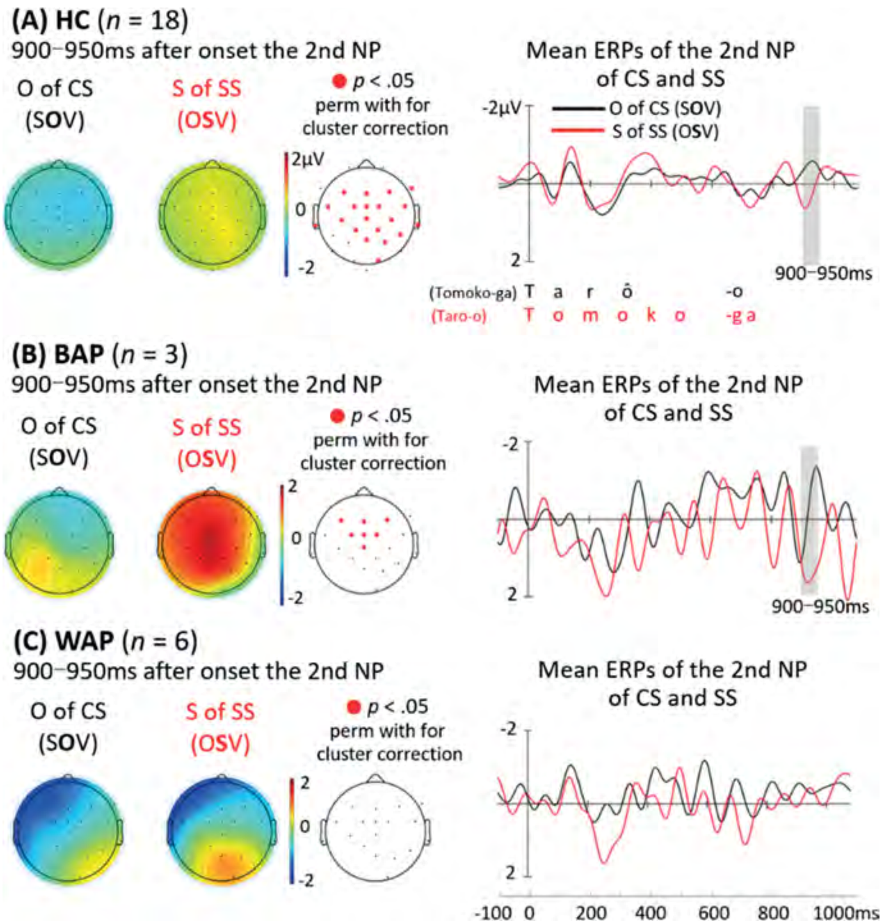

Figure 4: ERPs for hearing Japanese semantically reversible canonical sentences (CS) and scrambled sentences (SS) by native Japanese-speaking Broca's aphasia patients (BAP) and Wernicke's aphasia patients (WAP). In each panel, the time windows with significant differences are indicated with gray areas. Electrodes in red showed significant differences ($p < 0.05$ with cluster-based permutation test) between CS and SS. Panels (A), (B), and (C) indicate the findings of healthy controls (HC), BAP, WAP, respectively. S = subject; O = object; V = verb.

4 Discussion

This study attempted to examine the neural basis for auditory comprehension of syntactically and semantically demanding sentences in patients with aphasia. The hypothesis that BAP and WAP would elicit reduced and delayed P600 effects for SS relative to CS was partially supported. Only BAP yielded a positive ERP component for SS, but the timing was not delayed relative to the HC. The positivity shown in the HC was also considerably late for a P600, peaking around 900–950 ms after the second NP presentation for some reason, such as the modality difference with the previous ERP studies of Japanese sentence processing (i.e., auditory vs. visual). We interpret the positivity as a reflection of an extra processing load for involvement in the analysis of SS's complicated syntactic structure. Although BAP indicated an HC-like positive ERP component, WAP did not show any significant effects between SS and CS. As a reduced and delayed P600 effect for a syntactic violation found in Dutch BAP (Wassenaar and Hagoort 2005), the Japanese BAP's reduced positive ERP component for processing SS suggests that they are less sensitive to the complex syntactic structure in semantically ambiguous sentences than the HC. WAP, who revealed no ERP effect, may have more severe insensitivity to this kind of higher-level auditory syntactic processing.

The difference in ERP patterns for the semantically reversible SS between BAP and WAP was presumably from the different lesions they suffered. The lesions of the BAP are within the frontal areas, while those of the WAP extend from the frontal to the temporal areas. The finding that no expected ERP effects were found in the WAP with wider lesions in the temporal areas replicates the important role of the ventral pathway connecting the MTG and vlPFC via the extreme capsule, which has been proposed in the dual-stream model for auditory language processing (Hickok and Poeppel 2007; Saur et al. 2008). A previous fMRI study of visual comprehension of Japanese sentences in healthy young adults (Kim et al. 2009) shows that the anterior portion of the dual pathways, including the IFG and the dorsolateral prefrontal cortex in the left hemisphere, principally serves for processing the complicated syntactic analysis of SS. A lesion study (Kinno et al. 2009) also supports that regions responsible for syntactic processing through the visual modality are restricted in the anterior part of the frontal lobe, mainly including the IFG pars opercularis and pars triangularis. The lesion study of auditory sentence comprehension adds support for the function of the ventral pathway, including the frontal and temporal lobes, for efficient auditory language comprehension.

Nevertheless, this study has several limitations that will be addressed in future studies. First, employing many patients, we must conduct an in-depth analysis of each patient's anatomical characteristics in light of the dual pathways for auditory language processing based on their behavioral characteristics of linguistic comprehension. It allows for proposing more plausible interpretations of the ERP effects for semantically reversible SS and CS through the auditory modality. There is even more considerable variation in lesions among the actual population of patients with aphasia because Wassenaar and Hagoort's (2005) BAP affects many different regions not within the frontal and temporal lobes, extending to the insula and the internal capsule. Second, given that the present comparison between the SS and CS only concerned semantically reversible sentences always having animate NPs, it remains unclear how the obtained ERP effects for complex syntactic processing can change if the Japanese stimulus sentences are presented in a semantically unambiguous way (e.g., animacy of S and O is different), requiring no strict analysis of case markers. Third, the stimulus sentences were not presented in the same way as natural speech given the accurate acoustic control in the experiment. Although this study used the same sound files of NP for presenting S and O with constant pauses in between, pitch in naturally spoken sentences generally goes down from the beginning to the end, helping process complex sentence structures (Wolff et al. 2008). The constant prosody among NPs of the stimuli may somewhat impede effective sentence processing among participants. Finally, the long-term goal was to apply neurolinguistic findings for rehabilitation. We must develop an effective method of syntactic training with which patients recover their ability in comprehension and production of higher-level syntactic processing per the type of aphasia. The current clinical practice of Japanese aphasia treats patients by auditorily presenting a single SS and CS, asking them to select the picture that correctly depicts the sentence. Nevertheless, a speaker's use of SS is motivated by the presentation of the preceding context (e.g., Imamura 2015). An efficient solution for the patients to easily comprehend SS is then to utilize contextual information for stimulus preparation because the processing requirement for SS inevitably depends on its context, which reflects ERP patterns (Yano and Koizumi 2018) and behavior (Otsu 1994).

5 Conclusion

This ERP study of auditory processing of Japanese semantically reversible sentences with canonical and scrambled word orders in patients with aphasia demonstrated that native Japanese-speaking patients with BA, like their healthy counterparts, showed an ERP-P600 effect for processing scrambled word order relative to the canonical one. However, those with WA did not show any significant ERP effects. This finding suggests that patients with BA, whose lesions are limited within the frontal regions, sufficiently analyze case particles to comprehend complex syntactic structures with semantic ambiguity; whereas those with WA, whose lesions extend from the frontal to the temporal lobe, may have a functional disconnection for processing it. As per the recent dual-stream model for auditory language processing, the middle temporal lobe in the ventral pathway may be crucial in the auditory processing of complex sentences in aphasia patients.

Appendix A

Target sentences

	1st NP (CS/SS)					AdvP			2nd NP (CS/SS)					VP		
01	Tomoko	ga	/	Tarô	o	sensyû	no	nitiyôbi	Tarô	o	/	Tomoko	ga	home	ta	rasî
	Tomoko	NOM	/	Taro	ACC	last week	GEN	Sunday	Taro	ACC	/	Tomoko	NOM	praise	PST	seemingly
	"It seems that Tomoko praised Taro last Sunday."															
02	Makoto	ga	/	Akemi	o	kinô	no	yoru	Akemi	o	/	Makoto	ga	tasuke	ta	rasî
	Makoto	NOM	/	Akemi	ACC	yesterday	GEN	night	Akemi	ACC	/	Makoto	NOM	help	PST	seemingly
	"It seems that Makoto helped Akemi last night."															
03	Kazuko	ga	/	Jirô	o	ototoi	no	hiru	Jirô	o	/	Kazuko	ga	sasot	ta	rasî
	Kazuko	NOM	/	Jirô	ACC	day before yesterday	GEN	daytime	Jirô	ACC	/	Kazuko	NOM	invite	PST	seemingly
	"It seems that Kazuko invited Jiro the daytime before last."															
04	Kenji	ga	/	Junko	o	sensyû	no	getuyôbi	Junko	o	/	Kenji	ga	niran	da	rasî
	Kenji	NOM	/	Junko	ACC	last week	GEN	Monday	Junko	ACC	/	Kenji	NOM	glare at	PST	seemingly
	"It seems that Kenji glared at Junko last Monday."															
05	Hideki	ga	/	Yumiko	o	kotosi	no	haru	Yumiko	o	/	Hideki	ga	damasi	ta	rasî
	Hideki	NOM	/	Yumiko	ACC	this year	GEN	spring	Yumiko	ACC	/	Hideki	NOM	deceive	PST	seemingly
	"It seems that Hideki deceived Yumiko this spring."															
06	Naomi	ga	/	Tetuya	o	ototoi	no	yoru	Tetuya	o	/	Naomi	ga	nikun	da	rasî
	Naomi	NOM	/	Tetsuya	ACC	day before yesterday	GEN	night	Tetsuya	ACC	/	Naomi	NOM	hated	PST	seemingly
	"It seems that Naomi hated Tetsuya the night of the day before yesterday."															

(continued)

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	1st NP (CS/SS)					AdvP			2nd NP (CS/SS)					VP		
07	Asuka	ga	/	Yosio	o	sengetu	no	gezyun	Yosio	o	/	Asuka	ga	yurusi	ta	rasî
	Asuka	NOM	/	Yoshio	ACC	last month	GEN	end	Yoshio	ACC	/	Asuka	NOM	forgive	PST	seemingly
	"It seems that Asuka forgave Yoshio the end of last month."															
08	Akira	ga	/	Yûko	o	kinô	no	asa	Yûko	o	/	Akira	ga	seot	ta	rasî
	Akira	NOM	/	Yuko	ACC	yesterday	GEN	morning	Yuko	ACC	/	Akira	NOM	carry	PST	seemingly
	"It seems that Akira carried Yuka on his back yesterday morning."															
09	Osamu	ga	/	Megumi	o	kyonen	no	fuyu	Megumi	o	/	Osamu	ga	odosi	ta	rasî
	Osamu	NOM	/	Megumi	ACC	last year	GEN	winter	Megumi	ACC	/	Osamu	NOM	threaten	PST	seemingly
	"It seems that Osamu threatened Megumi last winter."															
10	Tuyosi	ga	/	Yôko	o	sensyû	no	kayôbi	Yôko	o	/	Tuyosi	ga	sidôsi	ta	rasî
	Tsuyoshi	NOM	/	Yoko	ACC	last week	GEN	Tuesday	Yoko	ACC	/	Tsuyoshi	NOM	guide	PST	seemingly
	"It seems that Tsuyoshi guided Yoko last Tuesday."															
11	Keiko	ga	/	Syôta	o	sensyû	no	kinyôbi	Syôta	o	/	Keiko	ga	utagat	ta	rasî
	Keiko	NOM	/	Syota	ACC	last week	GEN	Friday	Syota	ACC	/	Keiko	NOM	doubt	PST	seemingly
	"It seems that Keiko doubted Syota last Friday."															
12	Satoru	ga	/	Yukari	o	ototoi	no	yûgata	Yukari	o	/	Satoru	ga	tatai	ta	rasî
	Satoru	NOM	/	Yukari	ACC	day before yesterday	GEN	evening	Yukari	ACC	/	Satoru	NOM	hit	PST	seemingly
	"It seems that Satoru hit Yukari the evening of the day before yesterday."															
13	Ayumi	ga	/	Takasi	o	kyonen	no	haru	Takasi	o	/	Ayumi	ga	oikake	ta	rasî
	Ayumi	NOM	/	Takashi	ACC	last year	GEN	spring	Takashi	ACC	/	Ayumi	NOM	chase	PST	seemingly
	"It seems that Ayumi chased Takashi on last spring."															

14	Hanako	ga	/	Manabu	o	sengetu	no	tyûzyun	Manabu	o	/	Hanako	ga	sikat	ta	rasî
	Hanako	NOM	/	Manabu	ACC	last month	GEN	middle	Manabu	ACC	/	Hanako	NOM	scold	PST	seemingly
	"It seems that Hanako scolded Manabu the middle of last month."															
15	Atusi	ga	/	Humiko	o	kinô	no	hiru	Humiko	o	/	Atusi	ga	ket	ta	rasî
	Atsushi	NOM	/	Fumiko	ACC	yesterday	GEN	daytime	Fumiko	ACC	/	Atsushi	NOM	kick	PST	seemingly
	"It seems that Atsushi kicked Fumiko the daytime of yesterday."															
16	Kazuya	ga	/	Yosiko	o	kyonen	no	natu	Yosiko	o	/	Kazuya	ga	miokut	ta	rasî
	Kazuya	NOM	/	Yoshiko	ACC	last year	GEN	summer	Yoshiko	ACC	/	Kazuya	NOM	see off	PST	seemingly
	"It seems that Kazuya saw Yoshiko off last summer."															
17	Naoto	ga	/	Mituko	o	sensyû	no	suiyôbi	Mituko	o	/	Naoto	ga	hikkai	ta	rasî
	Naoto	NOM	/	Mitsuko	ACC	last week	GEN	Wednesday	Mitsuko	ACC	/	Naoto	NOM	scratch	PST	seemingly
	"It seems that Naoto scratched Mitsuko last Wednesday."															
18	Ryôta	ga	/	Yukie	o	kyô	no	asa	Yukie	o	/	Ryôta	ga	okosi	ta	rasî
	Ryota	NOM	/	Yukie	ACC	today	GEN	morning	Yukie	ACC	/	Ryota	NOM	wake up	PST	seemingly
	"It seems that Ryota woke up Yukie this morning."															
19	Takeo	ga	/	Setuko	o	sensyû	no	doyôbi	Setuko	o	/	Takeo	ga	nagut	ta	rasî
	Takeo	NOM	/	Setsuko	ACC	last week	GEN	Saturday	Setsuko	ACC	/	Takeo	NOM	hit	PST	seemingly
	"It seems that Takeo hit Setsuko last Saturday."															
20	Masao	ga	/	Yuriko	o	kyonen	no	aki	Yuriko	o	/	Masao	ga	yatot	ta	rasî
	Masao	NOM	/	Yuriko	ACC	last year	GEN	fall	Yuriko	ACC	/	Masao	NOM	hire	PST	seemingly
	"It seems that Masao hired Yuriko last fall."															
21	Manami	ga	/	Tadasi	o	ototoi	no	asa	Tadasi	o	/	Manami	ga	sagasi	ta	rasî
	Manami	NOM	/	Tadashi	ACC	day before yesterday	GEN	morning	Tadashi	ACC	/	Manami	NOM	look for	PST	seemingly
	"It seems that Manami looked for Tadashi the morning of the day before yesterday."															

(continued)

(continued)

	1st NP (CS/SS)					AdvP			2nd NP (CS/SS)					VP		
22	Noboru	ga	/	Miyoko	o	sengetu	no	syozyun	Miyoko	o	/	Noboru	ga	mituketa	ta	rasî
	Noboru	NOM	/	Miyoko	ACC	last month	GEN	beginning	Miyoko	ACC	/	Noboru	NOM	find	PST	seemingly
	"It seems that Noboru found Miyoko the beginning of last month."															
23	Noriko	ga	/	Tutomu	o	sensyû	no	mokuyôbi	Tutomu	o	/	Noriko	ga	sinji	ta	rasî
	Noriko	NOM	/	Tsutomu	ACC	last week	GEN	Thursday	Tsutomu	ACC	/	Noriko	NOM	believe	PST	seemingly
	"It seems that Noriko believed Tsutomu last Thursday."															
24	Minoru	ga	/	Kumiko	o	kinô	no	yûgata	Kumiko	o	/	Minoru	ga	tukamae	ta	rasî
	Minoru	NOM	/	Kumiko	ACC	yesterday	GEN	evening	Kumiko	ACC	/	Minoru	NOM	catch	PST	seemingly
	"It seems that Minoru caught Kumiko last evening."															
25	Makoto	ga	/	Kazuko	o	sensyû	no	nitiyôbi	Kazuko	o	/	Makoto	ga	home	ta	rasî
	Makoto	NOM	/	Kazuko	ACC	last week	GEN	Sunday	Kazuko	ACC	/	Makoto	NOM	praise	PST	seemingly
	"It seems that Makoto praised Kazuko last Sunday."															
26	Junko	ga	/	Jirô	o	kinô	no	yoru	Jirô	o	/	Junko	ga	tasuke	ta	rasî
	Junko	NOM	/	Jiro	ACC	yesterday	GEN	night	Jiro	ACC	/	Junko	NOM	help	PST	seemingly
	"It seems that Junko helped Jiro last night."															
27	Kenji	ga	/	Yumiko	o	ototoi	no	hiru	Yumiko	o	/	Kenji	ga	sasot	ta	rasî
	Kenji	NOM	/	Yumiko	ACC	day before yesterday	GEN	daytime	Yumiko	ACC	/	Kenji	NOM	invite	PST	seemingly
	"It seems that Kenji invited Yumiko the daytime before last."															
28	Naomi	ga	/	Hideki	o	sensyû	no	getuyôbi	Hideki	o	/	Naomi	ga	niran	da	rasî
	Naomi	NOM	/	Hideki	ACC	last week	GEN	Monday	Hideki	ACC	/	Naomi	NOM	glare at	PST	seemingly
	"It seems that Naomi glared at Hideki last Monday."															

29	Tomoko	ga	/	Tetuya	o	kotosi	no	haru	Tetuya	o	/	Tomoko	ga	damasi	ta	rasî
	Tomoko	NOM	/	Tetsuya	ACC	this year	GEN	spring	Tetsuya	ACC	/	Tomoko	NOM	deceive	PST	seemingly
	"It seems that Tomoko deceived Tetsuya this spring."															
30	Tarô	ga	/	Akemi	o	ototoi	no	yoru	Akemi	o	/	Tarô	ga	nikun	da	rasî
	Taro	NOM	/	Akemi	ACC	day before yesterday	GEN	night	Akemi	ACC	/	Taro	NOM	hated	PST	seemingly
	"It seems that Taro hated Akemi the night of the day before yesterday."															
31	Akira	ga	/	Megumi	o	sengetu	no	gezyun	Megumi	o	/	Akira	ga	yurusi	ta	rasî
	Akira	NOM	/	Megumi	ACC	last month	GEN	end	Megumi	ACC	/	Akira	NOM	forgive	PST	seemingly
	"It seems that Akira forgave Megumi the end of last month."															
32	Yôko	ga	/	Osamu	o	kinô	no	asa	Osamu	o	/	Yôko	ga	seot	ta	rasî
	Yoko	NOM	/	Osamu	ACC	yesterday	GEN	morning	Osamu	ACC	/	Yoko	NOM	carry	PST	seemingly
	"It seems that Yoko carried Osamu on his back yesterday morning."															
33	Keiko	ga	/	Tuyosi	o	kyonen	no	fuyu	Tuyosi	o	/	Keiko	ga	odosi	ta	rasî
	Keiko	NOM	/	Tsuyoshi	ACC	last year	GEN	winter	Tsuyoshi	ACC	/	Keiko	NOM	threaten	PST	seemingly
	"It seems that Keiko threatened Tsuyoshi last winter."															
34	Yukari	ga	/	Syôta	o	sensyû	no	kayôbi	Syôta	o	/	Yukari	ga	sidôsi	ta	rasî
	Yukari	NOM	/	Syota	ACC	last week	GEN	Tuesday	Syota	ACC	/	Yukari	NOM	guide	PST	seemingly
	"It seems that Yukari guided Syota last Tuesday."															
35	Satoru	ga	/	Asuka	o	sensyû	no	kinyôbi	Asuka	o	/	Satoru	ga	utagat	ta	rasî
	Satoru	NOM	/	Asuka	ACC	last week	GEN	Friday	Asuka	ACC	/	Satoru	NOM	doubt	PST	seemingly
	"It seems that Satoru doubted Asuka last Friday."															
36	Yûko	ga	/	Yosio	o	ototoi	no	yûgata	Yosio	o	/	Yûko	ga	tatai	ta	rasî
	Yuko	NOM	/	Yoshio	ACC	day before yesterday	GEN	evening	Yoshio	ACC	/	Yuko	NOM	hit	PST	seemingly
	"It seems that Yuko hit Yoshio the evening of the day before yesterday."															

(continued)

(continued)

	1st NP (CS/SS)					AdvP			2nd NP (CS/SS)					VP		
37	Manabu	ga	/	Humiko	o	kyonen	no	haru	Humiko	o	/	Manabu	ga	oikake	ta	rasî
	Manabu	NOM	/	Fumiko	ACC	last year	GEN	spring	Fumiko	ACC	/	Manabu	NOM	chase	PST	seemingly
	"It seems that Manabu chased Fumiko on last spring."															
38	Atusi	ga	/	Yosiko	o	sengetu	no	tyûzyun	Yosiko	o	/	Atusi	ga	sikat	ta	rasî
	Atsushi	NOM	/	Yoshiko	ACC	last month	GEN	middle	Yoshiko	ACC	/	Atsushi	NOM	scold	PST	seemingly
	"It seems that Atsushi scolded Yoshiko the middle of last month."															
39	Mituko	ga	/	Kazuya	o	kinô	no	hiru	Kazuya	o	/	Mituko	ga	ket	ta	rasî
	Mitsuko	NOM	/	Kazuya	ACC	yesterday	GEN	daytime	Kazuya	ACC	/	Mitsuko	NOM	kick	PST	seemingly
	"It seems that Mitsuko kicked Kazuya the daytime of yesterday."															
40	Yukie	ga	/	Naoto	o	kyonen	no	natu	Naoto	o	/	Yukie	ga	miokut	ta	rasî
	Yukie	NOM	/	Naoto	ACC	last year	GEN	summer	Naoto	ACC	/	Yukie	NOM	see off	PST	seemingly
	"It seems that Yukie saw Naoto off last summer."															
41	Ayumi	ga	/	Ryôta	o	sensyû	no	suiyôbi	Ryôta	o	/	Ayumi	ga	hikkai	ta	rasî
	Ayumi	NOM	/	Ryota	ACC	last week	GEN	Wednesday	Ryota	ACC	/	Ayumi	NOM	scratch	PST	seemingly
	"It seems that Ayumi scratched Ryota last Wednesday."															
42	Hanako	ga	/	Takasi	o	kyô	no	asa	Takasi	o	/	Hanako	ga	okosi	ta	rasî
	Hanako	NOM	/	Takashi	ACC	today	GEN	morning	Takashi	ACC	/	Hanako	NOM	wake up	PST	seemingly
	"It seems that Hanako woke up Takashi this morning."															
43	Manami	ga	/	Tutomu	o	sensyû	no	doyôbi	Tutomu	o	/	Manami	ga	nagut	ta	rasî
	Manami	NOM	/	Tsutomu	ACC	last week	GEN	Saturday	Tsutomu	ACC	/	Manami	NOM	hit	PST	seemingly
	"It seems that Manami hit Tsutomu last Saturday."															
44	Miyoko	ga	/	Tadasi	o	kyonen	no	aki	Tadasi	o	/	Miyoko	ga	yatot	ta	rasî
	Miyoko	NOM	/	Tadashi	ACC	last year	GEN	fall	Tadashi	ACC	/	Miyoko	NOM	hire	PST	seemingly
	"It seems that Miyoko hired Tadashi last fall."															

45	Noriko	ga	/	Noboru	o	ototoi	no	asa	Noboru	o	/	Noriko	ga	sagasi	ta	rasî
	Noriko	NOM	/	Noboru	ACC	day before yesterday	GEN	morning	Noboru	ACC	/	Noriko	NOM	look for	PST	seemingly
	“It seems that Noriko looked for Noboru the morning of the day before yesterday.”															
46	Kumiko	ga	/	Masao	o	sengetu	no	syozyun	Masao	o	/	Kumiko	ga	mituketa	ta	rasî
	Kumiko	NOM	/	Masao	ACC	last month	GEN	beginning	Masao	ACC	/	Kumiko	NOM	find	PST	seemingly
	“It seems that Kumiko found Masao the beginning of last month.”															
47	Minoru	ga	/	Setuko	o	sensyû	no	mokuyôbi	Setuko	o	/	Minoru	ga	sinji	ta	rasî
	Minoru	NOM	/	Setsuko	ACC	last week	GEN	Thursday	Setsuko	ACC	/	Minoru	NOM	believe	PST	seemingly
	“It seems that Minoru o believed Setsuko last Thursday.”															
48	Yuriko	ga	/	Takeo	o	kinô	no	yûgata	Takeo	o	/	Yuriko	ga	tukamae	ta	rasî
	Yuriko	NOM	/	Takeo	ACC	yesterday	GEN	evening	Takeo	ACC	/	Yuriko	NOM	catch	PST	seemingly
	“It seems that Minoru caught Kumiko last evening.”															

Notes: CS = canonical sentence; SS = scrambled sentence; NP = noun phrase; AdvP = adverb phrase; VP = verb phrase; NOM = nominative; ACC = accusative; GEN = genitive; PST = past.

Appendix B

Comprehension questions

a.	Questions asking the subject						
	Tarô	ga	home	masi	ta	ka?	
	Taro	NOM	praise	AUX	PST	INTER	
	"Did Taro praise (Tomoko)?"						
b.	Questions asking the object						
	Tarô	o	home	masi	ta	ka?	
	Taro	ACC	praise	AUX	PST	INTER	
	"Did (Tomoko) praise Taro? "						
c.	Questions asking the verb						
	Home	masi	ta	ka?			
	praise	AUX	PST	INTER			
	"Did (Tomoko or Taro) praise? "						
d.	Questions asking the adverb phrase						
	Sensyû	no	nitiyôbi	no	koto	desu	ka?
	last week	GEN	Sunday	GEN	thing	AUX-	INTER
	"Did it happen last Sunday? "						

Notes: NOM = nominative; ACC = accusative, AUX = auxiliary;
PST = past; INTER = interrogative; GEN = genitive.

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Kyoko Yamakoshi and Hiroyuki Shimada

Chapter 12 Experimental studies on clefts and right dislocations in child Japanese

1 Introduction

The acquisition of non-canonical word order sentences such as relative clauses and clefts in English and other languages has long received much attention in the literature (de Villiers et al. 1979; Tavakolian 1981; Friedmann, Belleti, and Rizzi 2009; Guasti, Statavrakaki, and Arosio 2012; Bever 1970; Lempert and Kinsbourne 1980; Aravind et al. 2016, Aravind, Hackl, and Wexler 2018; among others). Reportedly, children often have problems comprehending scrambled sentences that begin with objects in Japanese (Hayashibe 1975; Otsu 1994; Sano 2005). This chapter investigates whether children have problems with other non-canonical constructions beginning with objects such as Japanese clefts (JCs) and Japanese right dislocations (JRDs). We investigate three aspects of JCs and JRDs: word order, scope interaction, and associations of focus particles. These examinations show that children treat JCs and JRDs differently in the first and second aspects while showing similar non-adult-like behaviors in the third aspect. Hereafter we will refer to subject clefts as SCs, object clefts as OCs, subject right dislocations as SRDs, and object right dislocations as ORDs, but we will only use JCs and JRDs when the comparison between clefts and right dislocations in Japanese is important.

Section 2 examines Japanese children's comprehension of JCs and JRDs. Although their word orders are similar and objects can appear at the beginning of sentences, we show that children treat JCs and JRDs differently: they have problems with JCs, particularly with SCs but not with JRDs. Section 3 addresses a difference in the scope interaction between negation and the universal quantifier *zenbu* "all." It is reported that JCs exhibit an anti-reconstruction property with negation (Mihara and Hiraiwa 2006), but JRDs do not in adult Japanese. The results suggest that children are sensitive to the differences concerning these (anti-)reconstruction properties. Section 4 examines children's associations of focus particles in JCs and JRDs. Children exhibit similar incorrect associations of focus particles in JCs and JRDs, and we will discuss whether that is based on linear order or hierarchical structures based on c-command relations between subjects and objects. Section 5 presents the general discussion and conclusion.

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2 Children's comprehension of clefts and right dislocations in Japanese

As noted, Japanese children have problems with scrambled sentences beginning with objects (Hayashibe 1975; Sano 2005; see Otsu 1994 for the improvement with felicitous contexts). Hayashibe (1975) suggests that children may interpret the sentence-initial patient or theme as an agent (henceforth the Agent-first Strategy), as the canonical word order is SOV (s is subject; o, object; and v, verb) in Japanese. This Agent-first Strategy is also reported in English (Bever 1970; Slobin and Bever 1982; Abbot-Smith et al. 2017). This section probes whether children's Agent-first Strategy is observed in JCs and JRDs.

(1) a. Subject Cleft (SC)
[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."
b. Object Cleft (OC)
[Neko ga oikake-teiru no wa] inu (o) da.
cat NOM chase-PROG C TOP dog ACC COP
"It is a dog that the cat is chasing."

(2) a. Subject Right Dislocation (SRD)
Neko o oikake-teiru yo, inu ga.
cat ACC chase-PROG SFP dog NOM
"(It) is chasing the cat, the dog."
b. Object Right Dislocation (ORD)
Neko ga oikake-teiru yo, inu o.
cat NOM chase-PROG SFP dog ACC
"The cat is chasing (it), the dog."

In JCs (1), the bracketed presuppositional clause comes before the focused element (Kamio 1990; Sunagawa 2005). In SC (1a), the subject is focused, and the object comes at the beginning. Notably, the focused NP with the nominative case marker -*ga* in SCs shows low acceptability (Hoji 1987; Sadakane and Koizumi 1995; Mihara and Hiraiwa 2006; Hiraiwa and Ishihara 2012).[1] In OC (1b), the object is focused,

1 Hoji (1987), Sadakane and Koizumi (1995), Mihara and Hiraiwa (2006), and Hiraiwa and Ishihara (2012) note that the focused NP with the nominative case marker -*ga* shows very low acceptability in Japanese clefts. Regarding the focused NP with the accusative case marker -*o*, it seems more and the subject appears at the beginning. At the end of the presuppositional clause of JCs, the complementizer *no* and the topic marker *wa* appear.

In JRD (2), the part before the right-dislocated item normally ends with a sentence-final particle, such as *yo*, and a pause indicated by a comma. In SRD (2a), the subject is right-dislocated, and the nominative case marker *-ga* is attached. In ORD (2b), the object is right-dislocated and the accusative case marker *-o* is attached. The right-dislocated NPs are awkward without case markers or postpositions. According to Kuno (1978: 68), right-dislocated elements are elided in the first part of the sentence because they are judged recoverable from discourse contexts, and they are produced at the end of sentences for confirmation or to give supplementary information. Takami (1995: 160) notes that elements that can be right-dislocated in Japanese are items other than focus items.

Altinok (2020) and Tomioka (2021) propose that JRDs reflect the following strategy: "communicate the essential part of the informational content of the utterance as early as possible" (Tomioka 2021). As per their proposal, the essential part of the informational content of the utterance comes first in JRDs. We later discuss Altinok's (2020) and Tomioka's (2021) analyses in-depth. Here, it suffices to say that the information structures of JCs and JRDs seem to be somewhat opposite: In JCs, a presuppositional clause appears first, and the focus comes after, whereas in JRDs, the essential part of the informational content of an utterance comes first, and the non-focus item appears at the end.

Although the information structures of JCs and JRDs seem to be different, their word orders are quite similar, as shown in (1) and (2): OVS and SVO. Given that the object comes at the beginning in SCs and SRDs, children may use the Agent-first Strategy and misinterpret the sentence-initial object as an agent.

acceptable than that with the nominative case marker: Hoji (1987) used one question mark (?) and Sadakane and Koizumi (1995) used two question marks (??) for their judgements. Hiraiwa and Ishihara (2012) noted that the focused NP with the accusative case marker is accepted by some speakers, including the authors.

According to Hoji (1987, 1990) and Hiraiwa and Ishihara (2002, 2012), there are two types of Japanese clefts: case-marked and non-case-marked clefts. The most important difference between the two is the island sensitivity: the former is sensitive to islands, but not the latter. That is, the occurrence of movements is assumed in case-marked but not non-case-marked clefts. However, as noted, given that the clefts with the focused NPs with nominative case marker *-ga* are awkward, we dropped the nominative case marker *-ga* in SCs (i.e. subject clefts) and included the accusative case marker *-o* in OCs (i.e. object clefts) in our experiments in Section 2 and 3. The reason for including the accusative case marker *-o* in the experiments is that we assume the occurrence of movements in JCs and address reconstruction effects.

Children's performance of SCs and SRDs may then be much worse than that of OCs and ORDs. In this section, we examine children's comprehension of SCs, OCs, SRDs, and ORDs, in addition to scrambling.

2.1 Previous studies

2.1.1 Acquisition of clefts in English

Children acquiring English have problems with OCs around the age of 4 or 5 (Bever 1970; Lempert and Kinsbourne 1980). In English, in an SC, such as "It is a dog that is chasing the cat," the word order is SVO. In an OC, such as "It is a cat that the dog is chasing," the word order is OSV. English-speaking children may have problems with OCs because the object comes before the subject.

Aravind et al. (2016) and Aravind, Hackl, and Wexler (2018) show that children's performance becomes much better when felicitous contexts are given. They used the truth value judgment task with an illustration(Crain and Thornton 1998). Some context was given with the first picture hiding the focus with the black box, and the test sentence was given after the black box disappeared.

(3) a. Context: Look! The dog is chasing something, I wonder what it is.
b. Test sentence: It is a cat that the dog is chasing.

Children's responses in Aravind et al. (2016) were as follows: Matched SCs: 84%, Matched OCs: 83%, Mismatched SCs: 82%, Mismatched OCs: 34%. Children's performance of matched OCs, such as (3), was much better than the results of previous studies if the contexts were given with OCs, as in (3).

Our research group, however, notes that children's better performance for matched OCs may stem from experimental artifacts (Ohba, Sano, and Yamakoshi 2019). In the matched condition in (3), only two animals appeared in the pictures, and the focused animal was covered with a box. Children may respond correctly only by hearing the first part of the cleft sentence, "It is a cat." Therefore, we conducted the revised experiment with three-animal conditions, as reported in 2.2.[2]

2 Some studies examined the acquisition of Japanese clefts, but their results vary per experimental method [e.g., the act-out task in K. Sano (1977) and the picture-selection task in Dansako and Mizumoto (2007)]. Thus, we do not go into the details of such results here.

2.1.2 Acquisition of right dislocation in Japanese

Although no study, to the best of our knowledge, has conducted experiments on JRDs, some studies examine JRDs in children's naturalistic speech. Sugisaki (2005) examines whether wh-phrases appear in right-dislocated positions in children's natural speech data. Wh-phrases cannot be right-dislocated in Japanese because the right-dislocated items are not focused (Takami 1995; Tanaka 2001).[3] Sugisaki (2005) examines the utterances of two children (Aki: 2;6.15[4] – 3;0.0, Ryo: 2;4.25 – 3;0.30) in Miyata corpus (Miyata 2004a, b) in the CHILDES database (MacWhinney 2000). Table 1 shows the results.

Table 1: Children's utterances of subject-object-verb (S)OV and (S)VO sentences (Sugisaki 2005: 588).

	Aki		**Ryo**	
	(S) OV (canonical)	**(S)VO (i.e. ORD)**	**(S) OV (canonical)**	**(S)VO (i.e. ORD)**
Total #of utterances	518	38	252	43
# of direct object wh-question	185	0	40	0
% of wh-question	35.7%	0%	15.9%	0%

Aki produced 38 ORDs and Ryo produced 43 ORDs. Although they produced many object wh-questions in (S)OV order, they did not produce any ORDs with direct object wh-phrases. This contrast shows that they are sensitive to the constraint on JRDs.

Dansako (2018) examined SRDs in natural speech data of four children before the age of three in the CHILDES database and showed that children produced SRDs at the age of two and did not misuse the nominative case marker.

In summary, according to Sugisaki (2005) and Dansako (2018), children produce JRDs at the age of two, and they are sensitive to the constraint on JRDs. However, to the best of our knowledge, no prior studies have examined whether Japanese children misinterpret SRDs as they do in scrambling by using the Agent-first Strategy. Therefore, in our experiment, we examine children's interpretations of JRDs, especially SRDs, relative to JCs and scrambling.

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3 For more detailed explanations of why wh-phrases cannot occur in right-dislocated positions, see Tanaka (2001) and Sugisaki (2005). Further, Yamashita (2010) and Miyata (2018) noted that there is a prosodic factor that induces the prohibition of wh-phrases in right-dislocated positions; see Yamashita (2010) and Miyata (2018) for details.

4 The numbers represent the children's ages: years; months. days.

2.2 Experiment

Let us first present our research question and predictions for this experiment: [5]

(4) Research question and predictions
Do Japanese children apply the Agent-first Strategy to sentences that have sentence-initial objects? If so, children are expected to misinterpret not only scrambling but also SCs and SRDs, whereas they are not expected to misinterpret OCs and ORDs.

The subjects were 18 Japanese monolingual children (4;7-6;7, mean: 5;6) and 11 adults. We divided the children into two groups to test JCs and JRDs: the JC group (N = 9, 4;7-6;6, mean: 5;5) and the JRD group (N = 9, 4;8-6;7, mean: 5;7).

Although we followed the truth value judgment task used by Aravind et al. (2016) and Aravind, Hackl, and Wexler (2018), the scenarios involved three animals and two black boxes to avoid the experimental artifacts. As shown below, the context was given orally by the experimenter with the first picture on the computer screen (Figure 1). In the first picture, two animals are hidden by black boxes. When the second picture was shown, an anime character, Anpanman, appeared beside the second picture. The recorded test sentence was given as Anpanman's description of the second picture. The child was asked to judge whether the recorded test sentence was true or false based on the second picture.

Below are examples of SC, OC, SRD, ORD, and scrambling. In SC (5a), we did not include the nominative case marker with the focused subject given that its acceptability is low in adult speech (see also footnote 1). In OC (5b), the focused object was given with the accusative case marker. In SRD (5c) and ORD (5d), the right-dislocated NPs were given with the case markers.

(5) (Contexts)

Dareka	ga	zousan	o	aratte-ite,	
someone	NOM	elephant	ACC	wash-PROG	
zousan	ga	dareka	o	aratte-iru	yo.
elephant	NOM	someone	ACC	wash-PROG	SFP

5 Some parts of this experiment were originally reported in Shimada et al. (2020).

(Sample test sentences)

a. SC

Zousan	o	aratte-iru	no	wa	usisan	da.
elephant	ACC	wash-PROG	C	TOP	cow	COP

"It is a cow that is washing the elephant."

b. OC

Zousan	ga	aratte-iru	no	wa	usisan	o	da.
elephant	NOM	wash-PROG	C	TOP	cow	ACC	COP

"It is a cow that the elephant is washing."

c. SRD

Zousan	o	aratte-iru	yo,	usisan	ga.
elephant	ACC	wash-PROG	SFP	cow	NOM

"(It) is washing the elephant, the cow."

d. ORD

Zousan	ga	aratte-iru	yo,	usisan	o.
elephant	NOM	wash-PROG	SFP	cow	ACC

"The elephant is washing (it), the cow."

e. Scrambling

Zousan	o	usisan	ga	aratte-iru	yo.
elephant	ACC	cow	NOM	wash-PROG	SFP

"The elephant, a cow is washing."

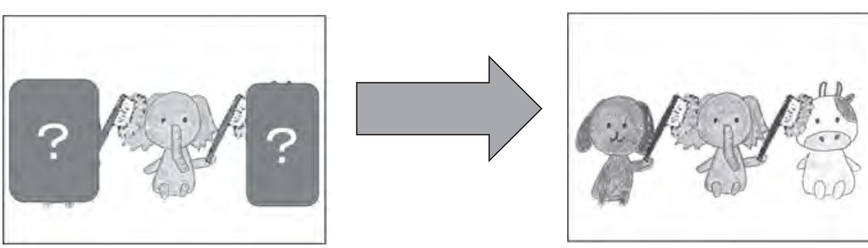


Figure 1: Pictures presented with the test sentences in (5).

We hid two animals because they are candidates for the focus. For example, in (5a), children first hear the accusative case-marked NP, *zousan-o* "elephant-ACC," and they may think that the elephant is a patient if they are aware of the accusative case marker. At the end of the sentence, they hear the focused NP, *usisan* "cow." This second NP is crucial for children to judge the test sentence. By listening to the end of the sentence, children must notice that the animal washing the elephant is not the cow but the dog. Therefore, by using three animals and two black boxes, we tried to exclude the possibility that children produce correct answers only by hearing the first case-marked NP. There were four trials (two true and false conditions) for SCs, OCs, SRDs, ORDs, and scrambling. We used two verbs throughout this experiment, *arau* “wash” and *oikakeru* “chase.” Moreover, four declarative test sentences for practice and four scrambled test sentences were included.

2.3 Results and discussion

Table 2 shows the results of the experiment:

Table 2: Correct Response Rates of Scrambling, Clefts, and Right Dislocations.

	Scrambling	**Subject Clefts (SCs)**	**Object Clefts (OCs)**	**Subject RD (SRDs)**	**Object RD (ORDs)**
Word Order	**OSV**	**OVS**	**SVO**	**OVS**	**SVO**
Children (JC: N=9, JRD:N=9)	56.9% (41/72)	52.8% (19/36)	91.7% (33/36)	86.1% (31/36)	100% (36/36)
Adults (N = 11)	100% (44/44)	100% (44/44)	100% (44/44)	100% (44/44)	100% (44/44)

First, the children’s correct response rate for scrambling was 56.9%, which is around the chance level. As we mentioned at the beginning of Section 2, Otsu (1994) used the Act-out task and showed that children aged 3 and 4 responded almost perfectly to scrambling when an appropriate discourse context showing the topic was given. In this experiment, however, given that two of three animals were covered with black boxes, the contexts we provided did not seem to help children comprehend scrambled test sentences.

Next, let us focus on the performance for SCs and OCs. The children’s correct response rate for SCs was 52.8%, and that for OCs was 91.7%. Clearly, children have difficulty comprehending SCs, where objects appear in the sentence-initial position. The OC performance was much better, probably because subjects, not objects, appeared at the beginning of OCs. When we consider the results of scrambling and SCs, we suggest that children are using the Agent-first Strategy to comprehend scrambling and SCs.[6]

6 We suggested this possibility in Ohba, Sano, and Yamakoshi (2019). Intriguingly, Sano (2020) tested children’s comprehension of JCs with the first NP showing location with the particle *-ni*, such as

Now we focus on the results for SRDs and ORDs. The correct response rate for SRDs is 86.1%, and that for ORDs is 100%. Although the objects appeared at the beginning of SRDs, it is surprising that children's performance for SRDs was much better than that for scrambling and SCs.[7] These results suggest that children do not always use the Agent-first Strategy even when objects appear in a sentence-initial position.[8] Alternatively, the Agent-first Strategy may still be in effect in JRDs but another factor such as information structure, which we introduce below, may override the effect of the Agent-first Strategy.

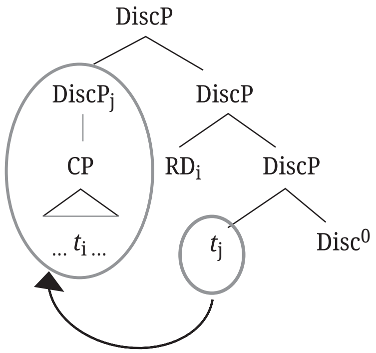
Why are children good at JRDs but not SCs or scrambling? Altinok's (2020) and Tomioka's (2021) analyses of the information structure of JRDs may provide some insight. According to their analysis, JRDs have the following strategy: "communicate the essential part of the informational content of the utterance as early as possible" (Tomioka 2021). They propose the following structure for JRDs: the dislocated element moves to the specifier of the Discourse Phrase, and the rest of the sentence undergoes the remnant movement from the complement of $Disc^0$ and adjoins above the dislocated element in Spec, Discourse P. Let us call this approach the Discourse Phrase Approach.

Buta-ni not-teiru no wa dare kana? (Pig-LOC ride-PROG C TOP who Q) "Who is it that is riding on the pig?" As the children's correct response rates were above 90%, he concluded that children do not use the Agent-first Strategy when the particle attached to the first NP is *-ni*. Therefore, the further issue is to determine when children (do not) use the Agent-first Strategy.

7 One of the reviewers noted that the presence of a case marker in JRDs and its absence in JCs might have affected children's performance. In (5a), we did not attach the nominative case marker with the subject in the focus position, as it is said to be unacceptable to many speakers, noted in footnote 1. However, in (5b), a nominative case marker *-ga* is attached to the right-dislocated subject *usisan* "cow." (5b) becomes awkward when the right-dislocated item is without the nominative case marker *-ga*. Generally, right-dislocated NPs do not sound well if case markers or postpositions are not attached. The presence or the absence of case markers may be one of the factors affecting children's performance with JCs and JRDs. We would like to investigate this issue further in future research.

8 One of the reviewers suggested that the difference between the results of SCs and SRDs in our experiment might indicate that the hypothesis of the Agent-first Strategy is not correct. However, effects of the Agent-first Strategy have long been reported in other constructions in Japanese, Korean, and Chinese such as scrambling (Hayashibe 1975), relative clauses (Suzuki 2011) and passives (Huang et al. 2013 in Chinese; Deen et al. 2018 in Korean). Thus, we assume the presence of the Agent-first Strategy and its effect on children's comprehension of SCs in Japanese.

(6)



(Altinok 2020: 10; Tomioka 2021)

According to the proposed strategy of JRD (i.e., "Communicate the essential part of the informational content of the utterance as early as possible") (Tomioka 2021), the essential part of the informational content of the utterance comes first in JRDs. Accordingly, JRDs may be much easier for children to comprehend than SCs and scrambled sentences.

Altinok (2020) and Tomioka (2021) also note that a predicate is a core ingredient of JRDs. If their analysis is right, predicates, including subjects and objects, come at the beginning of JRDs, which may make them easier for children to comprehend. However, in SCs, the presuppositional clause at the beginning in clefts may not be the core ingredient of a sentence, and because the object appears at the beginning, it may be more challenging for children to comprehend SCs, unlike SRDs. Regarding scrambling, the predicate (i.e., the verb) comes at the end of the sentence in Japanese; thus, it might be one of the causes of children's challenges with scrambling.[9]

When we consider "the essential part of the informational content of the utterance" (Tomioka 2021), children's processing of SCs and SRDs may be different. Some studies examine Japanese adults' processing of JCs and JRDs (Kahraman et al. 2011; Yano, Tateyama, and Sakamoto 2015; Soshi and Hagiwara 2004),[10] but to the best of

9 Sugiura (2022) examines children's comprehension of multiple JRDs, with VSO and VOS word orders. Sugiura finds that children were good at VSO and VOS, showing that they are good at JRDs in general. It is not clear how children interpret SO and OS orders in VSO or VOS well based on the Discourse Phrase approach. See Sugisaki et al. (2014) for the acquisition of VOS/VSO orders in Kaqchikel.

10 Kahraman et al. (2011) examine the processing of SCs and OCs with adults using a self-paced reading task and shows that adults used more reading time for SCs than OCs. These results coincide with our children's results. However, Yano, Tateyama, and Sakamoto (2015) present different results in their ERP study. According to them, P600 amplitudes with OCs were larger than those with SCs, indicating that SCs are easier to process than OCs. It seems to be contradictory to Kahraman et al.'s (2011) results. Soshi and Hagiwara (2004) conduct an ERP study of JRDs with adults and show our knowledge, no previous studies examine children's processing of JCs and JRDs. Future research must investigate Japanese children's processing of JCs and JRDs to explore the causes of the difference between SCs and SRDs.

3 Children's comprehension of scope interactions in Japanese clefts and Japanese right dislocations

3.1 The (anti-)reconstruction properties of Japanese clefts and Japanese right dislocations

In this section, we focus on another aspect in which children show different behaviors between JCs and JRDs. Let us consider the scope interactions in JCs and JRDs. Notably, JCs exhibit a reconstruction property in sentences without negation, but they exhibit an anti-reconstruction property with negation (Hoji 1987; Mihara and Hiraiwa 2006; Nishigauchi and Fujii 2006; a.o.):

(7) a. Taro ga Δ seme-ta no wa zibunzisin o da.
Taro NOM blame-PAST C TOP himself ACC COP
"It was himself that Taro blamed." (Mihara and Hiraiwa 2006: 265)

b. Huta-ri no syoonen ga Δ utaw-ta no wa
2-CL GEN boy NOM sing-PAST C TOP
samba o 3-kyoku da.
samba ACC 3-CL COP
"It was three sambas that (the) two boys sang."
(^{OK} 3>2 =collective, ^{OK} 2>3=distributive) (Nishigauchi and Fujii 2006: 10)

that the positivity effect of argument JRDs is P345, which is different from the study of JCs by Yano, Tateyama, and Sakamoto (2015). Soshi and Hagiwara (2004) also note that the positivity effect of argument JRDs was observed in the left frontal and temporal areas, which was not found with adjunct JRDs. They argue that this positivity effect is a syntactic integration process of dislocated arguments. Although the studies were conducted with adults, they may give us hints to understand children's comprehension of JCs and JRDs.

(8) a. *Taro ga Δ tabe-nakat-ta no wa ringo-sika da.
Taro NOM eat-NEG-PAST C TOP apple-FOC COP
lit. It was only an apple that Taro ate.

b. Taro ga Δ tabe-nakat-ta no wa ringo zenbu da.
Taro NOM eat-NEG-PAST C TOP apple all COP
"It was all the apples that Taro didn't eat." (^{ok} all>neg, *neg>all)

In (7) are examples of JCs without negation. In (7a), *zibunzisin* "self" in the focus position can be bound and coindexed by *Taro*, the subject in the presuppositional clause. According to Mihara and Hiraiwa (2006), *zibunzisin* seems to be reconstructed in the object position, shown by Δ, in the presuppositional clause at LF. In (7b), Nishigauchi and Fujii (2006) suggest that the focused quantified object is reconstructed into the position of Δ in the presuppositional clause and is within the c-command domain at LF. The operation of reconstruction yields the distributive reading.

There are various syntactic analyses of JCs, such as the null operator movement analysis by Matsuda (1997), Hoji and Ueyama (1998), and Kizu (2005), the string-vacuous verb movement, remnant movement and the operator movement analysis by Koizumi (1995), and the direct movement analysis by Hiraiwa and Ishihara (2012). Here we do not choose a particular analysis, but we assume a focused element is moved from its original position to the focused position in JCs. Thus, the reconstruction effect can be seen in (7).

In (8) are examples of JCs with negation. In (8a), *ringo-sika* "nothing but the apple" cannot appear in the focus position. XP+*sika* is a Negative Polarity Item (NPI), and it must be c-commanded by negation internally (Kishimoto 2018: 7), but the ungrammaticality of (8a) shows that *ringo-sika* cannot be reconstructed in the canonical object position under negation in the presuppositional clause, which is called the anti-reconstruction property. Mihara and Hiraiwa (2006: 265) also present similar examples to show the anti-reconstruction property of JCs. In (8b), *ringo zenbu* "apple all" can appear in the focus position, but it cannot have a scope under negation, which also shows that it cannot be reconstructed under negation in the presuppositional clause. Thus, in (8b), the all>neg, not the neg>all, interpretation, is acceptable. (8a) and (8b) show the anti-reconstruction properties of JCs.

Contrary to JCs, as in JRD (9a), the NPI *LGB-sika* "nothing but LGB" can be right-dislocated in a negative sentence. It shows that *LGB-sika* is reconstructed in the canonical position, as shown by Δ, and *LGB-sika* is c-commanded by negation in the position of Δ.

(9) a. Taro ga Δ yom-anak-atta yo, LGB-sika.
Taro NOM read-NEG-PAST SFP LGB-FOC
"(lit.) Taro read only LGB." (Takita, 2011: 382)
b. Taro ga Δ tabe-nakat-ta yo, ringo zenbu o.
Taro NOM eat-NEG-PAST SFP apple all ACC
"Taro didn't eat, all the apples." (^{ok} all>neg, ^{ok} neg>all)

In (9b), all>neg and neg>all interpretations are possible, which means that *ringo zenbu* "apple all" can be reconstructed in the canonical position, and the negation can have wide scope over *ringo zenbu*, unlike the cleft sentence in (8b). Therefore, (9a) and (9b) show that JRDs allow for the reconstruction of right-dislocated elements. Let us call it the reconstruction property of JRDs.

There are several syntactic approaches proposed for JRDs: for example, the rightward movement approaches by Haraguchi (1973), leftward movement approaches, such as the double preposing analysis by Kurogi (2006), and the bi-clausal repetition and deletion analysis by Kuno (1978), Whitman (2000), Abe (2004), Takita (2011), Yamashita (2011). Here we do not focus on a particular analysis; we assume the movement of the dislocated element is involved from its original position to the dislocated position. Thus, the reconstruction effects are observed in (9).

In summary, although JCs and JRDs have similar non-canonical word orders, there is a difference in their reconstruction properties: in negative sentences, JCs have an anti-reconstruction property, and JRDs have a reconstruction property. The following table summarizes such properties. To our knowledge, no previous studies have examined children's knowledge of these properties. Therefore, in this section, we examine whether Japanese children are sensitive to the (anti-)reconstruction properties of JCs and JRDs. In the experiment, we focus on the cases with negation, as in Table 3.

Table 3: Availability of reconstruction in JCs and JRDs.

	Reconstruction in JCs	**Reconstruction in JRDs**
without neg	✓	✓
with neg	*	✓

3.2 Experiment

The following is the research question and predictions for this experiment: [11]

(10) Research question and predictions
Do Japanese children know of the anti-reconstruction property of JCs and the reconstruction property of JRDs? If so, Japanese children should reject neg>all readings in JCs but accept neg>all readings in JRDs when they interpret the scope interaction between negation and the universal quantifier.

We tested 20 Japanese monolingual children (4;8 – 6;6) and 23 adult native speakers of Japanese using the truth value judgment task (Crain and Thornton 1998). We divided the subjects into two groups. In the JC group, there were 10 children (4;11 – 6;6, mean=5;8) and 12 adults, and we tested whether the children would reject neg>all readings and whether they would accept all>neg readings for JCs. In the JRD group, there were 10 children (4;8 – 6;6, mean=5;9) and 11 adults, and we tested whether they would accept neg>all and all>neg readings for JRDs.

The test sentences in the main session were as follows.[12] In the JC (JRD) group, we used two JCs (JRDs) with neg>all contexts and two JCs (JRDs) with all>neg contexts. The test sentences were recorded and given after short stories were presented with pictures. Apart from the last picture, an anime character Anpanman appeared, and the test sentences were given as an explanation of a story uttered by Anpanman. The children were asked to judge whether the test sentence that Anpanman gave was true or false.

The following is an example of the contexts for neg>all readings and the test sentences. The same stories were used for JC and JRD groups. (11) and (12) give the story, the last picture of the story, and the test sentences in the JC and JRD groups (see Figure 2).

(11) (Context for the neg>all reading) There are a mouse and a dog. The teacher told them to have sweets and vegetables. The mouse should take a tomato and a piece of cake, and the dog should take a pudding and three green peppers. The mouse took a piece of cake but left the tomato because it did not like tomatoes. The dog took one pudding. The dog should have taken all the green peppers, but it did not want to take them because it did not like green

11 This experiment was originally reported in Okada et al. (2019).

12 The practice session involved two canonical sentences, two JCs or two JRDs, in each group with negation and one JC or JRD with *zenbu* "all" to examine whether the children knew the meanings of negation and *zenbu*. All the subjects passed the practice session.

peppers. However, the dog remembered what the teacher said. Therefore, the dog took two of the three green peppers but left one.

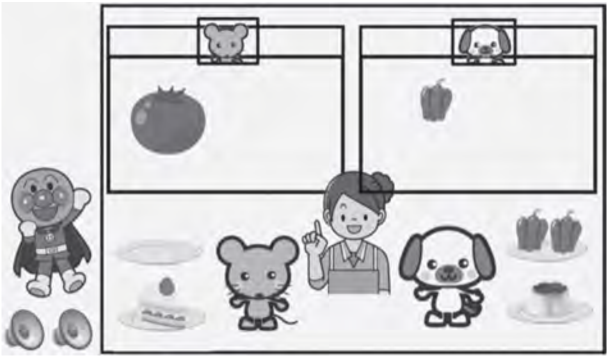


Figure 2: Last picture of the story (11).

(12) Test sentences in JC group and JRD group

a. JC (^{ok}all>neg, *neg>all)

Inu-san	ga	Δ	tora-nakat-ta	no	wa
dog	NOM		take-NEG-PAST	C	TOP

piiman	zenbu	o	da	yo.
green pepper	all	ACC	COP	SFP

"It is all the green peppers that the dog didn't take."

b. JRD (^{ok}all>neg, ^{ok}neg>all)

Inu-san	ga	Δ	tora-nakat-ta	yo,	piiman	zenbu	o.
dog	NOM		take-NEG-PAST	SFP	green pepper	all	ACC

"The dog didn't take, all the green peppers."

Given that (12a) is a JC, the focus *piiman zenbu-o* "green pepper all-ACC" cannot be reconstructed in the presuppositional clause, and the negation cannot take wide scope over the quantifier *zenbu* "all." Hence only the all>neg reading is allowed. We expected that children would reject (12a) if they only allowed the all>neg reading because the dog left one green pepper at the end of the story.

(12b) is a JRD, and the right-dislocated object *piiman zenbu-o* "green pepper all-ACC" can be reconstructed to the canonical position Δ, which means all>neg and neg>all readings are allowed. We expected that children would accept (12b) if they allowed the neg>all reading because the dog took two green peppers but not three.

Concerning the contexts for all>neg readings, for example, one animal took none of the vegetables. In JCs, the focused *zenbu* "all" cannot be reconstructed under negation. Thus, children should have accepted all>neg readings if they knew the anti-reconstruction property of JCs. However, in JRDs, children should have accepted or rejected all>neg readings if they are aware of the reconstruction property of JRDs.

3.3 Results and discussion

Tables 4 and 5 show the results of the experiment.

Table 4: Acceptance rates of the Japanese clefts group.

	Neg>all reading (*)	All>neg reading (OK)
Children (N=10)	10.0% (2/20)	90.0% (18/20)
Adults (N=12)	0.0% (0/24)	100.0% (24/24)

Table 5: Acceptance rates of the Japanese right dislocations group.

	Neg>all reading (OK)	All>neg reading (OK)
Children (N=10)	60.0% (12/20)	100% (20/20)
Adults (N=11)	54.5% (12/22)	95.5% (21/22)

Table 4 shows the acceptance rates of the JC group. Children's acceptance rate of all>neg readings was 90.0%, whereas that of neg>all readings was 10.0%. Thus, most of the children correctly assigned all>neg readings to JCs. Adults' acceptance rate of all>neg readings was 100% and that of neg>all readings was 0%. Hence, adults rejected neg>all readings for all JCs, and children and adults comprehended JCs quite similarly. These results suggest that children are aware of the anti-reconstruction property of JCs.[13]

Table 5 shows the acceptance rates of the JRD group. Children's acceptance rate of all>neg readings was 100%, and that of neg>all readings was 60.0%. These results show that more than half of the children accepted the two readings of JRDs per the

13 We presented similar observation concerning the scope assignment in JCs including focused elements without case markers in Shimada et al. (2019).

context. Adults' acceptance rate of all>neg readings was 95.5%, and that of neg>all readings was 54.5%.[14] The results show that children and adults behaved quite similarly, which suggests that children know the reconstruction property of JRDs.

As for the children's differences between JCs and JRDs, the children mostly rejected neg>all readings in the JC group (10% acceptance, which means 90% rejection), but they accepted neg>all readings 60% of the time in the JRD group. This difference suggests that children are aware of the difference between JCs and JRDs concerning the scope interaction between negation and the universal quantifier *zenbu* "all."

Furthermore, the research group tested whether children are sensitive to the reconstruction property of JCs when they are without negation by using test sentences similar to (7b) in another experiment (see Shimada et al. 2019). We tested 14 children (4;3 – 6;6, mean: 5;5). Given that the children allowed for the distributive readings 85.7% (24/28) of the time, the results show that children are sensitive to the reconstruction property of JCs without negation and the anti-reconstruction property of JCs with negation.

In summary, although the word orders of JCs and JRDs are similar, the experiment shows that children differentiate JCs and JRDs when they interpret scope interactions. These results suggest that children know the anti-reconstruction property of JCs with negation, the reconstruction property of JCs without negation (Shimada et al. 2019), and the reconstruction property of JRDs regardless of the presence of negation.

In Sections 2 and 3, we have shown that children treated JCs and JRDs differently. In the next section, we will show that children make incorrect associations of focus particles in JCs and JRDs.

14 Reviewers note children's and adults' low acceptance rates for neg>all readings. In the test sentences of our experiment, we used an accusative case marker *–o* with *zenbu* "all." When the accusative case marker is attached to the quantifier *zenbu* "all" in negative sentences, both all>neg and neg>all readings should be available, but it seems that there is a preference for all>neg readings with the accusative case marker *-o*. This preference may stem from the presence of the contrastive topic marker *-wa* in Japanese. When the contrastive marker *-wa* is attached to *zenbu* "all" instead of the accusative case marker *-o*, only neg>all readings are acceptable (Kato 1985, McGloin 1987, a.o.) In Goro (2007), similar experimental results were given with the test sentences, including phrases such as *omocha-o zenbu* "toy-ACC all," and children's acceptance rate of neg>all readings was 42.5% (p. 317). As Goro suggested, given the presence of the contrastive marker *-wa*, which yields only neg>all readings in negative sentences with *zenbu* "all," adults and children in our experiment may have accepted all>neg readings more easily when the accusative case marker *-o* was attached to *zenbu* "all." Terunuma (2003) tested children's interpretation of *zenbu-wa* "all-TOP" with negation, and the children accepted neg>all readings more than 87% of the time, suggesting that children are sensitive to the difference between *zenbu-o* "all-ACC" and *zenbu-wa* "all-TOP."

4 Children's comprehension of focus particles in Japanese clefts and Japanese right dislocations

This section addresses children's incorrect associations of *dake/sika* "only" in JCs and JRDs. In English, Crain, Ni, and Conway (1994) and Notley et al. (2009) report on children's incorrect association of *only*. When *only* modifies the subject NP as in "Only the cat is holding a flag" in test sentences, children often incorrectly associate the sentence-initial *only* as if it modifies the VP as in "The cat is only holding a flag." However, when *only* is placed before VP in test sentences, it seems that children do not often incorrectly associate *only* with subject NPs. Hence, there is subject-object asymmetry in children's wrong associations of *only* in English. Crain, Ni, and Conway (1994) and Notley et al. (2009) suggest that children interpret *only* as a sentential modifier as follows: [Only (the cat is holding a flag)]. *Only* c-commands and modifies all phrases in the rest of the sentence, and, thus, children misinterpret *only* attached to the subject as modifying the VP or the object. In Japanese, Endo (2004) examine Japanese children's interpretations of the focus particles *sika/dake* "only" in canonical SOV sentences; she also observed subject-object asymmetry in Japanese.

(13) shows examples of *dake* and *sika* in canonical SOV sentences:

(13) a. Inusan-dake ga densya o kat-ta yo.
dog-FOC NOM train ACC buy-PAST SFP
"Only the dog bought a train."
b. Inusan-sika densya o kawa-nakat-ta yo.
dog-FOC train ACC buy-NEG-PAST SFP
"Only the dog bought a train."

In (13a), the focus particle *dake*, corresponding to "only," is attached to the subject before the nominative case marker *-ga*. In (13b), *sika*, an NPI corresponding to "nothing but," is attached to the subject without a case marker. Unlike *only* in English, because *dake* and *sika* do not appear in a sentence-initial position, one might expect that Japanese children do not associate these focus particles incorrectly. However, as noted, the behavior of children acquiring Japanese was quite similar to that of children acquiring English. (Endo, 2004).[15] Crain, Ni, and Conway

15 Further, Sano (2012) tests whether Japanese children incorrectly associate *dake* attached to subjects in scrambled sentences. He finds that the incorrect association is still observed when objects are scrambled before subjects, which suggests that scrambled objects are reconstructed to the canonical position (SOV).

(1994) and Notley et al. (2009) suggest that children's wrong associations stem from the position of *only* in syntactic hierarchical structures (i.e., c-command relation), but it remains unclear whether the wrong associations are because of linear order or hierarchical structures. In the children's structure they suggested [Only (the cat is holding a flag)], *only* can be associated with the first or second NP by focusing on its linear order, or *only* can be associated with the subject or object NP based on the hierarchical structure because *only* c-commands both.

The experiments aim to ascertain whether Japanese children wrongly associate *dake/sika* in non-canonical word order sentences, such as JCs and JRDs, and whether subject-object asymmetry is observed. Given that the focus particles in Japanese, such as -*dake* and -*sika*, are attached to XPs, and they cannot stand alone, what we mean by wrong association is that the focus particle attached to an NP is somehow associated with another NP in test sentences.

We can make different predictions for children's wrong associations based on the surface linear order or the c-command relation in JCs and JRDs. Children may wrongly associate the focus particle with another NP based on surface linear order: for example, the focus particle attached to objects may be wrongly associated with subjects in OVS sentences based on linear order because objects appear before subjects linearly. However, the focus particle attached to objects may not be wrongly associated with subjects if children's wrong associations are based on the c-command relation between subjects and objects of the canonical word order, SOV. Regarding the c-command relation between subjects and objects of the canonical word order, we assume focused items in JCs and right-dislocated items in JRDs are reconstructed to the original positions of the canonical word order hierarchically. The experimental results suggest that children incorrectly associate focus particles based on the c-command relation of the canonical word order, SOV, and that children reconstruct the focused items in JCs and the right-dislocated items in JRDs to the original positions of the canonical word order.[16] The next subsections will detail the experiment and results.

16 From the results in Section 3, Japanese children know the anti-reconstruction property of JCs with negation, the reconstruction property of JCs without negation (Shimada et al. 2019), and the reconstruction property of JRDs regardless of the presence of negation. Test sentences in Section 4 do not include negation; thus, children can reconstruct dislocated items to original positions in JCs and JRDs.

4.1 Experiment

The research question for this experiment is as follows.[17]

(14) Research question
Do Japanese children incorrectly associate focus particles in non-canonical word order sentences, such as JCs and JRDs? If so, is it based on linear order or hierarchical structure (i.e., the c-command relation between subjects and objects in the canonical word order after reconstruction)?

Table 6 shows the types of test sentences we used and the predictions based on surface linear order or hierarchical structure.

Table 6: Predictions of the experiment.

Test sentence types	Surface linear order	Reconstructed canonical structure	Hierarchical structure after reconstruction
(i) canonical: **[Focused S]** O V	(A)Yes	–	(B) Yes
(ii) canonical: S **[Focused O]** V	(C) No	–	(D) No
(iii) JC/JRD: **[Focused S]** V(,) O	(E) Yes	**[Focused S]** O V	(F) Yes
(iv) JC/JRD: **[Focused O]** V(,) S	(G) Yes	S **[Focused O]** V	(H) No
(v) JC/JRD: O V(,) **[Focused S]**	(I) No	**[Focused S]** O V	(J) Yes
(vi) JC/JRD: S V(,) **[Focused O]**	(K) No	S **[Focused O]** V	(L) No

[Focused X] means that the focus particle *dake* or *sika* is attached to the subject (S) or object (O). "Yes" ("No") shows that children's wrong associations are (not) predicted.

As mentioned in Section 3 (also in footnote 1), movements are involved in JCs and JRDs. If wrong associations occur based on surface linear order, they should occur based on the linear order after movements. However, if wrong associations occur based on reconstructed structures, wrong associations should occur based on the hierarchical structure of the canonical word order after reconstruction.

Type (i) (**[Focused S]** OV) and Type (ii) (S **[Focused O]** V) are canonical word order sentences. As noted, prior studies, such as Endo (2004), have shown that wrong associations occur frequently in (i), not (ii), and we predicted that it would be the same in cells (A), (B), (C), and (D).

17 Some parts of this experiment were originally reported in Mochizuki, Shimada, and Yamakoshi (2021) and Shimada, Mochizuki, and Yamakoshi (2022).

In Type (iii) **([Focused S]** V(,) O), the focus particle is attached to the subject. The surface linear order is SVO, and wrong association with the object is predicted in cell (E) because the subject appears before the object based on the surface linear order. Next, the word order after reconstruction becomes SOV, and the subject c-commands the object. Thus, the wrong association with the object is also predicted in cell (F) since the subject c-commands the object in the reconstructed structure.

In Type (iv) (**[Focused O]** V(,) S), the object with the focus particle appears in the sentence-initial position. Thus, wrong association with the subject at the end is predicted in cell (G) based on the surface linear order OVS. However, if children reconstruct the sentence-initial object to its canonical position based on its hierarchical structure, the word order becomes SOV, and wrong association with the subject is not predicted in cell (H) since the object is c-commanded by the subject.

In Type (v) (O V(,) **[Focused S])**, on the surface linear order OVS, the subject with the focus particle is at the end of the sentence; thus, wrong association with the object is not predicted in cell (I). However, if children reconstruct the subject to the canonical position, the word order becomes SOV, and the subject c-commands the object. Hence wrong association is predicted in cell (J).

In Type (vi) (S V(,) **[Focused O])**, the focus particle is attached to the object at the end of the sentence. On the surface linear order SVO, wrong association with the subject is not predicted in cell (K) because the object appears after the subject linearly. If wrong associations occur based on the reconstructed structure, the word order after reconstruction becomes SOV. Wrong association with the subject is also not predicted in cell (L), as the object does not c-command the subject in the canonical word order.

In summary, as highlighted in gray in Table 6, predictions differ. If children's incorrect associations of the focus particles stem from surface linear order, wrong associations are predicted to occur in Types (iii) and (iv). However, if children's incorrect associations stem from hierarchical structures after reconstruction, then wrong associations are predicted to occur in Types (iii) and (v).

We conducted the JC and JRD experiments at different times, but the same stories and pictures were used. In the JC experiment, the subjects were 10 Japanese monolingual children (5;7 – 6;5, mean: 6:0). We used the focus particle *dake* exclusively because *sika* cannot appear in the focused position in JCs, as in Section 3. In the JRD experiment, the subjects were 16 Japanese monolingual children (5;2 – 6;10). We tested *dake* and *sika* for the JRD experiment and divided the children into two groups: *dake* (5;7 – 6;7, mean: 6;3) and *sika* (5;2 – 6;10, mean: 6;2) groups. The method was the truth value judgment task (Crain and Thornton 1998). Short stories were presented by an experimenter with pictures on a computer screen. After each story, an anime character, Anpanman, appeared beside the picture and a recorded test sentence was given as Anpanman's description of the story. Children were asked to judge whether a test sentence by Anpanman was true or false. From Table 6, the experiment included two canonical word order sentences and four types of target sentences. Each type comprised two trials, one with a matched and one with a mismatched condition. We also included a practice session and four filler items during the main session.

Consider examples of the test sentences for Type (ii) (**[Focused O]** V(,) S) and the picture below: [18]

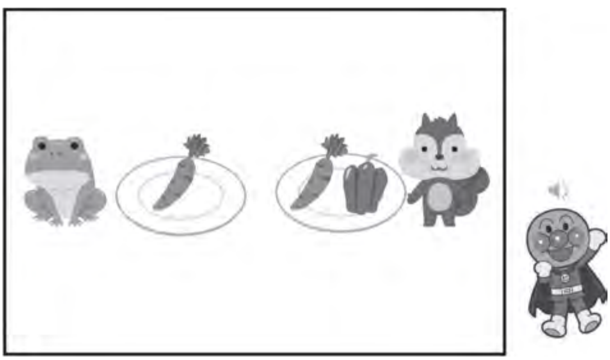


Figure 3: Picture presented with the test sentences in (15).

(15) (Context)
Experimenter: The squirrel took a carrot and a pepper. Now Anpanman will talk about the frog. (This was originally given in Japanese and translated into English)
(Test sentences)
a. JC (with *dake*)

Ninjin-dake	o	tot-ta	no	wa	kaerusan	da	yo.
carrot-FOC	ACC	take-PAST	C	TOP	frog	COP	SFP

"It was a frog who took only the carrot."

18 In the JC experiment in Section 4, we conducted the experiment separately from other experiments and did not attach the nominative case marker or accusative case *marker* with the focused NP. It was desirable if the accusative marker was attached to the object NPs in the focus position, as in Section 2 and 3. We suppose the absence or presence of the accusative case marker here did not change our results very much. Furthermore, Sugawara (2016) conducted experiments to test children's comprehension of *only* in English using Question-Answer Congruence (QAC) (Rooth 1985, von Stechow 1990.) In this experiment, we could not include discourse contexts based on QAC, but we aim to probe contexts considering QAC for a future research.

b. JRD (with *dake*)
Ninjin-dake o tot-ta yo, kaerusan ga.
carrot-FOC ACC take-PAST SFP frog NOM
"(She/he) took only the carrot, the frog."

c. JRD (with *sika*)
Ninjin-sika tora-nakat-ta yo, kaerusan ga.
carrot-FOC take-NEG-PAST SFP frog NOM
"(She/he) took only the carrot, the frog."

In JC (15a), *dake* is attached to the object at the beginning of the JC. If a child comprehends it correctly, this test sentence is true because the frog only took a carrot in the story. As *dake* is attached to the first NP *ninjin* "carrot," children can wrongly associate *dake* with the second NP *kaerusan* "frog" based on the surface linear order. If children's wrong associations are based on the hierarchical structure after reconstruction, the word order after reconstruction is S O-*dake* V, and children should not associate *dake* with the subject NP *kaerusan* "frog" because the subject is structurally higher than the subject and the object+*dake* does not c-command the subject. In JRDs (15b, c) with *dake* and *sika*, the focus particle is attached to the object *ninjin* "carrot" and the same prediction as in (15a) would apply.

4.2 Results and discussion

The results of the experiment are shown in Table 7:

Table 7: Children's correct response rates in JCs and JRDs.

	JCs	JRDs	
	***dake* (N = 10)**	***dake* (N = 8)**	***sika* (N = 8)**
(i) **[Focused S]** O V	45.0% (9/20)	56.3% (9/16)	50.0% (8/16)
(ii) S **[Focused O]** V	90.0% (18/20)	87.5% (14/16)	81.3% (13/16)
(iii) **[Focused S]** V(,) O	30.0% (6/20)	31.3% (5/16)	25.0% (4/16)
(iv) **[Focused O]** V(,) S	95.0% (19/20)	81.3% (13/16)	93.8% (15/16)
(v) O V(,) **[Focused S]**	55.0% (11/20)	25.0% (4/16)	31.3% (5/16)
(vi) S V(,) **[Focused O]**	90.0% (18/20)	81.3% (13/16)	100% (16/16)

As for the canonical word order sentence types (i) and (ii), the results were quite similar to those of Endo (2004). The correct response rates for Type (i) highlighted in gray are not high because children wrongly associated the focus particle attached to subjects with objects. However, the correct response rates for Type (ii) are high, above 80%, because children did not wrongly associate the focus particle attached to objects with subjects. Namely, subject-object asymmetry is observed in (i) and (ii), as reported at the beginning of this section.

In the JC and JRD experiments, the correct response rates for Types (iii) and (v) highlighted in gray were quite low, mostly around 30%, whereas those for Types (iv) and (vi) were quite high, above 80%. The children showed the same tendencies in JCs and JRDs, and there seemed not to be much difference between *dake* and *sika*. These results show that children make wrong associations frequently when the focus particle is attached to subjects but less often when attached to objects, regardless of the positions of subjects and objects on surface linear order. The results clearly show that there is subject-object asymmetry in children's wrong association of focus particles in JCs and JRDs.

As presented in Table 6, our prediction was as follows: if children's wrong associations are based on surface linear order, the correct response rates for Types (iii) and (iv) were expected to be low, and those for Types (v) and (vi) were expected to be high in the JC and JRD experiments; however, that was not the case. The children responded to Types (iii) and (v) with low correct response rates but Types (iv) and (vi) with high rates. These results suggest that the children in the JC and JRD experiments incorrectly associated the focus particles based on the reconstructed hierarchical structures.

Notably, these results do not contradict the results for scope interactions in Section 3. In Section 3, children are sensitive to the reconstruction property of JCs without negation and the anti-reconstruction property of JCs with negation. Furthermore, children are sensitive to the reconstruction property of JRDs regardless of the presence of negation. Given that the test sentences in this section are without negation, the results suggest that the children reconstructed focused and right-dislocated items to canonical positions in JCs and JRDs and that children's incorrect associations of the focus particles *dake* and *sika* stem from the hierarchical structures after the reconstruction of subjects or objects in JCs and JRDs.

5 General discussion and conclusion

This study focused on three aspects of the acquisition of JCs and JRDs: word order, scope interactions, and association of the focus particles. From the results of the experiments, children seem to be sensitive to differences between JCs and JRDs concerning word order and scope interactions, while they show similar behaviors for the wrong associations of focus particles. Section 2 examined whether children use the Agent-first Strategy (Bever 1970, Hayashibe 1975) when they interpret JCs and JRDs. The results show that children have difficulty with SCs, and we suggested that children apply the Agent-first Strategy for SCs. However, children did not have problems with SRDs. If children also use the Agent-first Strategy for SRDs, SCs and SRDs should be problematic for them, but the results revealed that the children had troubles with SCs but not with OCs, SRDs, or ORDs.

Thus, to probe the reason for this difference, we suggested that the Discourse Phrase Approach (Altinok 2020, Tomioka 2021) may provide insight: the sentence-initial part in JRDs is an "essential part of the informational content of the utterance" (Tomioka 2021). However, the sentence-initial part in JCs is a presuppositional clause; thus, it may be easier for children to comprehend JRDs than JCs, particularly SCs. As noted, the Agent-first Strategy may still be at work in JRDs, but the importance of the sentence-initial part in its information structure of JRDs suggested by Tomioka (2021) may override the effect of the Agent-first Strategy. Hence, children's performance for JRDs is quite good relative to that for JCs. Another factor with sentence processing may be also related: In JCs, the sentence does not end after the presuppositional clause. It is followed by the complementizer *no*, the topic marker *wa*, the focus element, and the copula *da*. In JRDs, however, the sentence is suspended with the sentence-final particle *yo* and a pause showed by a comma before the right-dislocated item. This difference between JCs and JRDs may explain the difference in children's performance between JCs and JRDs, and children's processing of JCs and JRDs requires further investigation. In summary, despite the similarities between JCs and JRDs concerning their word order, this study has shown that children clearly distinguish JCs and JRDs.

Section 3 provided another piece of evidence showing that children are aware of the difference between JCs and JRDs: the anti-reconstruction property of JCs and the reconstruction property of JRDs. We tested the scope interaction between negation and an NP modified by the universal quantifier *zenbu* "all." The results show that children know the (anti-)reconstruction properties of JCs and JRDs, and children know the differences between JCs and JRDs.

In Section 4, we examined children's incorrect associations of the focus particles *dake/sika* "only/nothing but" in JCs and JRDs. In JCs and JRDs, children wrongly associated *dake* and *sika* frequently when the particles were attached to subjects but not objects, and subject-object asymmetry was observed. Children are probably aware of the difference in the syntactic structures between JCs and JRDs, and they know how to reconstruct those into the structures with canonical word order because their incorrect associations of the focus particles seem to occur after reconstruction. We must further investigate how children capture the syntactic structures of JCs and JRDs and why children's incorrect associations of focus particles occur by examining other various aspects of the acquisition of JCs and JRDs.

Abbreviations

ACC	accusative
CL	classifier
COP	copula
FOC	focus
JC	Japanese cleft
JRD	Japanese right dislocation
LOC	locative
NEG	negation
NOM	nominative
OC	object cleft
ORD	object right dislocation
PROG	progressive
SFP	sentence-final particle
SC	subject cleft
SRD	subject right dislocation
TOP	topic

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Chapter 13
Developmental changes in the interpretation of an ambiguous structure and an ambiguous prosodic cue in Japanese

1 Introduction

This chapter investigates whether adults and children abide by the same processing bias when encountering a global structural ambiguity and whether they share a common understanding of what certain prosodic phenomena signal in resolving the ambiguity. The first question is whether young children exhibit an adult-like processing bias (a local interpretation of a modifier), which supposedly results from an advantage in incremental processing. It is worth investigating because young children may not be as efficient as adults in processing continuous input as rapidly as it is received. The second question concerns how prosodic information is used by children, particularly in the case of a prosodic signal potentially associated with two different roles, namely, as a signal to syntactic structure and as a signal indicating contrastive status. We consider one instance of branching ambiguity in Japanese.

1.1 Branching ambiguity in Japanese

Studies on adults' online processing of three-part noun phrases with a branching ambiguity in Japanese, such as (1) report an overall preference for the interpretation with the left-branching (LB) structure over the interpretation with the right-branching (RB) structure (Ito, Arai, and Hirose 2015; Hirose 2020).

(1) ao'i ne'ko-no ka'sa-wa doko
blue cat-Gen umbrella-Top where
a. Left-branching (LB)
"Where's the umbrella with blue cats on it?"
[[ao'i ne'ko]-no ka'sa]-wa doko?
b. Right-branching (RB)
"Where's the blue umbrella with cats on it?"
[ao'i [ne'ko-no ka'sa]]-wa doko?

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This preference is expected from a processing perspective. That is, human sentence processing operates incrementally, continuously assigning syntactic structure to input that unfolds over time; head-final languages, such as Japanese are no exception (Inoue 1991; Inoue and Fodor 1995; among many others). In the example above (modifier + N1Gen + N2), the only available head for the modifier (*ao'i* "blue") at the point where N1 is processed is that very N1 (*ne'ko* "cat(s)"), thus determining the node dominating *ao'i* + *ne'ko*, which will lead the entire NP to the LB configuration (i.e., that blue-colored cats are on an umbrella). For the RB structure to be assigned to the NP, the association between the modifier and its head would have to be postponed until the final or third element (*ka'sa* "umbrella") is processed, overriding the pressure for an immediate association between the modifier and its modificand. The RB structure is treated as a marked interpretation at the phonology-syntax interface (Kubozono 1988) in that it requires distinct prosodic marking (such as *metrical boost*), as will be discussed in-depth in the following section. If the overall preference for the LB over the RB structure mainly stems from the human parser's incremental nature, the branching bias may be different in populations where comprehenders may not comply with the pressure for immediate or incremental processing as rapidly as adults (Snedeker and Yuan 2008; Ito et al. 2014; Hirose and Mazuka 2017).

One reason to assume RB structure can be more accessible for children is that children tend to resort to the *intersective* interpretation reported by Matthei (1982). In that study, children misinterpreted phrases such as *the second green ball*, choosing a green ball in the second position in an array (where the first ball was in some other color, thus making the green ball the first green ball). Linguists often expect that children's preferences in interpreting syntactically ambiguous word strings can reveal their grammatical knowledge. Matthei (1982) accounted for the so-called intersective reading as revealing the lack of an intermediate node dominating [green ball]. Instead of constructing such a hierarchical structure for the noun phrase *the second green ball*, the children adopted a non-hierarchical structure in which both *second* and *green* are assigned positions on the same level as that of the head noun *ball*. This explanation accords with Pérez-Leroux et al. (2018), where children (4–6 years of age) had more difficulty producing NPs requiring recursive modification than NPs calling for sequential modification without recursive embedding.

An alternative account of such phenomena, proposed by Hamburger and Crain (1984), posits that the apparent inability to compute a hierarchical structure reported in Matthei (1982) stems from children's performance errors. This account can accord with the idea that children's interpretive bias stems from the ease of computing the structure for the intersective reading relative to computing the structure for the correct reading.

If we could set aside the advantage of LB structure in incremental processing, RB structure could be generated, and perhaps processed, with more ease. Fujita

(2017) distinguished the syntactic operations by which (1a) and (1b) are generated as Pot-Merge and Sub-Merge, respectively, as an analogy to concepts proposed in action grammar (Greenfield 1991), generalizing the strategies by which non-linguistic actions are controlled by children. In Pot- and Sub-Merge, there are two steps of Merge. In Pot-Merge, the target of both Merge operations is fixed; thus, both the intermediate node and the top node would have the same label. In Sub-Merge, the first Merge step targets the head of the intermediate node, which then merges with another head, the head of the entire phrase, resulting in a structure in which the intermediate node and the top node have different labels. Fujita argued that Sub-Merge is more taxing on human working memory, as it requires a sub-unit to be stored in the process. The difference between these Merge types is not automatically linked to the branching directions, but when applied to the two alternative structures in question [i.e., (1)], the RB structure would be generated through Pot-Merge while the LB structure would have to undergo Sub-Merge. The difference then would explain the higher cost of generating and perhaps processing the LB structure, independent of its incremental advantage, which children may not enjoy to the same extent as adults. This is the first question we will set out to answer: Do young children have a processing bias in branching ambiguities? Is it different from the LB bias of adults?

1.2 The role of pitch prominence in resolving branching ambiguities

Pitch prominence in Japanese has multiple functions, allowing certain prosodic signals to induce more than one way of interpreting an utterance at different linguistic levels. First, the Japanese pitch accent is directly linked to the lexical accent. Whether a Japanese lexical word is accented or unaccented is specified in the lexicon. Ota, Yamane, and Mazuka (2018) demonstrated that the ability to use pitch information to recognize words develops after 17 months.

Pitch prominence also plays a role in projecting the syntactic structure. Studies show that pitch prominence contributes to distinguishing two noun phrases comprising three elements configured differently (Kubozono 1988; Ito, Arai, and Hirose 2015; Hirose 2020). The LB structure can provide a downstepping domain throughout the entire NP. Downstep is a phonological phenomenon where an accented word lowers the H peak of the following word within the downstep domain. In (1a), the downstep should occur over the three words *ao'i, ne'ko-no,* and *ka'sa*, which are all accented, producing a staircase-like f0 contour. Thus, the H peak of *ne'ko* in *ao'i ne'ko* ("blue cat") in (1a) is realized lower than the same word in, for example, *akai ne'ko* ("red cat"), which is not preceded by an accented word (*akai* is an unaccented word).

The realization of downstep is affected by the syntactic structure behind the three words (Kubozono 1988; Selkirk and Tateishi 1991). The downstep that would occur on the second word (*ne'ko* ["cat"], as in [1b]) is interfered with at the left edge of an RB structure. The second word, *ne'ko*, is realized with an elevated pitch, which appears to cancel out the declination of the f0 peak because of a downstep. The nature of such interference is under debate. One interpretation is that the left edge of the RB structure is associated with a prosodic boundary, thereby resetting the domain of downstep (Pierrehumbert and Beckman 1988; Selkirk and Tateishi 1991). An alternative interpretation maintains that the downstep continues over the three words but the f0 of the H peak is realized higher at the left edge of an RB structure, still within the same prosodic phrase; it is called metrical boost (Kubozono 1988). Both accounts presuppose that the prosodic difference associated with the two branching structures is derived from the grammatical knowledge controlling the correspondence between syntax and prosody.

There is yet another level of information that pitch accent is responsible for encoding in speech. In Japanese, like many other languages, pitch prominence can express discourse and information status conveyed by focus (Ito et al. 2012; Jincho, Oishi, and Mazuka 2019). Focus prosody can emphasize new information relative to old or given information, the target of a question expressed with a wh-phrase, and contrastive information. Focus prosody comprises a notable pitch elevation on the focused element, followed by compression of the pitch range continuing up to the end of the focus domain (i.e., post-focal reduction; see Ishihara 2011).

In perception, to understand whether the input being processed is in linguistic focus, listeners must recognize the pitch elevation on the focused element and the post-focal reduction that follows to decide on the domain of the focus. However, evidence from sentence processing shows that listeners rely mainly on pitch elevation on the focused item alone (Kitagawa and Hirose 2012). It accords with the human parser's real-time decision-making about the linguistic status of incoming input being incremental in nature; the parser makes interpretations without waiting for the confirming information that may be provided by later input, such as, in this case, post-focal reduction.

1.3 Resolving the ambiguity in pitch prominence to resolve branching ambiguities

The discussion thus far establishes the possibility that the same acoustic event, namely an increase in the peak f0 height of an accented word, could stem from the prosodic phenomena driven by the syntactic structure (whether metrical boost or reset, associated with the RB syntax) or a focus event (the word is pronounced with focus prominence). The subsequent input would provide additional information to decide which factor is responsible for the rise. For example, if *ao'i ne'ko-no ka'sa* ("blue cat-$_{GEN}$ umbrella") is realized with a notable pitch rise on *ne'ko* ("cat"), instead of downstep continuing on all three items, it could be perceived as evidence for the RB syntax. The later input would have to accord with this interpretation; that is, the rest of the input would have to accord with an RB structure comprising three elements, not four (because a sequence of four elements would be subject to rhythmic boost (Kubozono 1989) and an f0 raising effect that can result in reorganizing a four-word syntactic structure into two prosodic minor phrases, overriding the f0 contour expected by the application of metrical boost). If, however, a listener is to guess which interpretation the incoming input *ao'i ne'ko-no* would be associated with, the pitch rise on *ne'ko* would be a useful clue to expect (1b), with the RB structure.

The situation becomes more complicated if one is choosing from the two possible alternative structures, LB and RB, in a situation where context provides room for contrastive interpretations (Ito, Arai, and Hirose 2015). For example, the pitch prominence on *ne'ko* could stem from contrastive focus to emphasize the information *ne'ko* as opposed to possible alternatives (e.g., some other animal that is also blue). Again, the elevated pitch alone would not be sufficient to determine the word's focus status without evidence for the occurrence of post-focus pitch compression on the subsequent input. If the background information (i.e., preceding context or the situation in which the expression is heard) does not provide any context in which *ne'ko* could stand in a contrastive relationship with some other entity, there may be no motivation to assign the focus interpretation to the prosodic event. However, if the contrastive context is properly induced (e.g., by the presence of another entity that is also blue), listeners may be anticipating that the appropriate part of the input will receive focus prosody.

Hirose (2020) conducted a series of visual world paradigm eye-tracking experiments using Japanese sentences such as (1a, b), one with downstep throughout the NP, the other with a pitch rise on the second word (e.g., *ne'ko*), to investigate how such ambiguous prosodic information (namely, a pitch rise on the second item of an NP consisting of three accented items) is interpreted in real-time processing. In one of the experiments using pictures, such as the one presented in Figure 1, where the contrastive interpretation of the pitch rise is felicitous in the visual context (given the presence of blue squirrels on an umbrella), the LB target attracted more looks relative to the RB target as soon as the second word in question became available.

This outcome was considered evidence that the pitch rise information induced a contrastive interpretation (e.g., it is the cat that is blue, not the squirrel) based on the input available at that point, which accords more with the LB interpretation of the entire set of experimental materials (because there was only one visual object

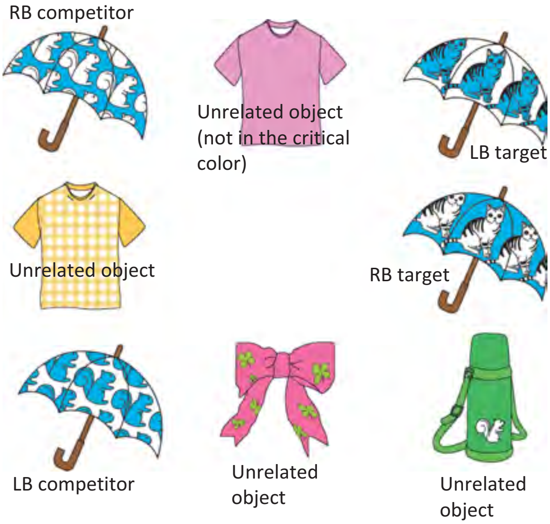

Figure 1: Example visual scene for the ambiguous item exemplified in (1). The color used for the four umbrellas (whether applied to the background of the umbrellas or the animal illustrations decorating the umbrellas) was the same (blue in this example).

with a blue cat on it). Backing up this explanation, the study also reported that the same pattern was not observed when the picture did not have possible competitors appropriate for the contrastive interpretation.

Interestingly, toward the end of such a sentence, when the listeners had to finalize their interpretation to perform the task (clicking on the most appropriate picture), the sentences that had the pitch rise on the second word (W2) induced more looks to the RB target relative to the LB target. By the time the entire input was received, and it was evident that the input involved a three-part NP, which means the condition for the metrical boost was provided, the parser had re-interpreted the pitch phenomenon as a signal to the RB syntax. This finding shows that adult Japanese listeners can efficiently and flexibly use the same prosodic cue differently at different times during the processing of a sentence, making the prosodic signal useful regarding whatever partial information is available at each point during the process. In this study, however, the identical acoustic signals resulted in different interpretations per the visual context alone. Importantly, the results also accorded with the view that syntax-marking prosodic cues are understood independently from context or situation (Speer, Warren, and Schafer 2011), as the W2 rise eventually induced an increase in the RB interpretation regardless of the contextual manipulation.

1.4 How do children cope with prosodic ambiguity and syntactic ambiguity?

It is worth further investigating whether young children's interpretations follow the same patterns as adults' interpretations. Children's behavior in such contexts is relevant to multiple questions. First, when do children learn to process complex phrases comprising three elements with a branching ambiguity?

Several studies in different languages report varying degrees of sensitivity of children to prosodic information that marks phrase and clause boundaries (Choi and Mazuka 2003; Carvalho, Dautriche, and Christophe 2016; Carvalho et al. 2016; Snedeker and Yuan 2008). Regarding pitch accents in Japanese, Ito et al. (2012) show that six-year-olds are sensitive to pitch accents in real-time contrast resolution in color Adjective + Noun (where the color information is contrastive) in Japanese. Jincho, Oishi, and Mazuka (2019) further test six- and five-year-olds using similar visual materials to Ito et al. (2012), except that the manipulations in contrastive status were realized in the visual context rather than prosody. They observed a facilitation effect of the contrastive information in six-year-olds but not in five-year-olds.

Young children's sensitivity to pitch information regarding the resolution of syntactic branching ambiguities has yet to be documented. If the Japanese children have acquired the association between a certain pattern of the F0 contour and the RB syntax and that with contrastive focus, there remains the question of whether adults and children always share a common understanding of what certain prosodic phenomena signal in a given context. Children should have learned that the RB structure is somewhat marked and, therefore, must be prosodically signaled by a rising pitch on the edge of the right-branching node (whether that pitch change is placing a prosodic boundary or applying a metrical boost). It further presupposes that children can construct and process LB and RB syntactic structures to recognize the difference, which requires the ability to handle the hierarchical configurations of the phrase structures in question. Moreover, children would have to be sensitive to how contrastive status is reflected by linguistic and prosodic features. They would need to know how contrastive focus is encoded in the prosodic representation, which corresponds to the syntactic representation. If either knowledge type (how RB structures and contrastive focus are encoded in prosody) remains unavailable in real-time comprehension, we will not see the adult-like patterns reported above in children's data.

Whether the speed and efficiency with which children apply the relevant knowledge in real-time processing differ from that of adults is another issue. In general, visual world paradigm research shows that children's eye responses to linguistic information are subject to delay by several hundred milliseconds relative to adults' (Trueswell et al. 1999; Arnold 2008; Snedeker and Yuan 2008). Regarding the real-time use of pitch accent information, studies report that elementary school children (six to 11 years of age) are subject to a 400 ms delay (Ito et al. 2014; Hirose and Mazuka 2017).

Beyond timing differences, children at age six demonstrate the ability to utilize pitch accent information when processing contrastive status in an online task, but they need more time than adults to redirect their attention between tasks to correctly interpret the contrastive prosody (Ito et al. 2012). If children's online response to contrastive pitch accent is subject to a sizable delay in the same task as that used in Hirose (2020), the immediate effect of W2 pitch rise (facilitating the LB interpretation via the contrastive interpretation of the pitch rise) may not be observed early enough, even if the effect is present. Alternatively, by the time the W2 pitch rise is recognized and processed for its function, subsequent information inducing the alternative interpretation of the pitch rise information perceived earlier (e.g., as a signal to the RB syntax) may already have become available, canceling out the contrastive interpretation of the pitch rise. If the contrastive interpretation is not computed quickly, the bias toward the LB target may not occur, as the association of the contrastive interpretation of the pitch rise on the first N (e.g., *ne'ko*) and the LB interpretation presupposes the immediate and very local computation of the Adjective + N, without considering the alternative branching structure that becomes available when the subsequent N (e.g., *ka'sa*) obtains it. This outcome is most likely for young children.

Our main goal is to investigate the period within which the branching structure is determined and whether and how the prosodic information plays a role for young children. We compared two groups of three- and four-year-old children.

2 Experiment

A visual world paradigm experiment, using nearly identical stimuli to Hirose (2020), was conducted with native Japanese-speaking children.

2.1 Method

2.1.1 Participants

The child participants comprised 28 three-year-olds and 25 four-year-olds, recruited at Riken Brain Science Institute; their parents received a small payment. All the children resided in the vicinity of Wako-city, Saitama, and their parents were all speakers of Tokyo Japanese.

2.1.2 Materials

2.1.2.1 Linguistic stimuli

The experimental sentences were the same as in Hirose (2020). The critical materials comprised 12 experimental audio items of the form: [color word] + N1-Gen + N2-Top, followed by *wa dore* ("which one"), as exemplified in (1), repeated here.

(2) ao'i ne'ko-no ka'sa-wa do're?
blue cat-Gen umbrella-Top which
'Which one is the umbrella with blue cats / the blue umbrella with cats?'
(Note: Japanese does not have a number distinction; *ne'ko* is compatible with both a single cat or multiple cats.)

All three constituents of the NP were lexically accented words (hence subject to downstep if they form an LB structure). There were also 12 filler audio items with no branching ambiguity or particular pitch emphasis, which were also included in the experiment. Some of the fillers mentioned the color or pattern of an (a) entire (part of an) object, in both cases using various syntactic forms.

The audio materials were recorded by a female speaker of Tokyo Japanese who was familiar with Japanese phonology. Each item came in two audio versions. In one, the speaker had been asked to read the item to express the intended meaning of the LB interpretation. This version was the *downstep (default prosody) condition*. In the other version, the speaker had been asked to have the RB interpretation in mind. The second words (e.g., *ne'ko*) were pronounced with a raised pitch (relative to the first version) to counteract downstep. This version was the *W2 pitch rise condition*. Table 1 summarizes the relevant measurements of the experimental audio stimuli.

Table 1: Acoustic profiles of the relevant parts (i.e., the syntactically ambiguous noun phrases) of the audio stimuli (mean duration and mean peak f0 values over 12 items. Figures in parentheses are standard deviations).

	color word		**N1**		**Gen**		**N2**	
condition	Dur (ms)	f0 (Hz)	Dur (ms)	f0 (Hz)	Dur (ms)	f0 (Hz)	Dur (ms)	f0 (Hz)
downstep	875 (166)	401 (18)	697 (142)	346 (16)	250 (25)	270 (23)	869 (158)	281 (18)
W2 rise	853 (151)	387 (19)	693 (143)	421 (9)	223 (22)	338 (26)	854 (150)	275 (7)

In all items, the second constituent and its genitive-marking particle in the downstep condition had significantly lower f0 peaks than their counterparts in the W2 pitch rise condition of at least 50Hz, yielding a significant difference between the

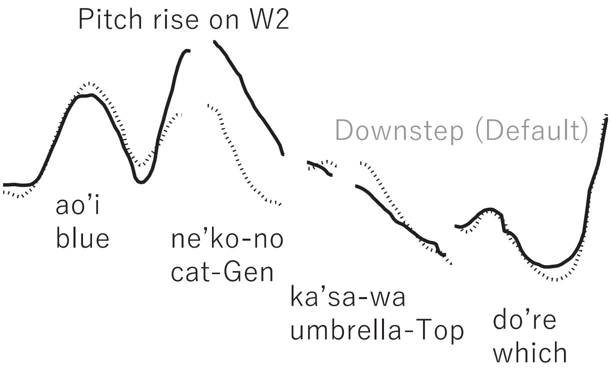

Figure 2: A sample pitch track of the experimental item (1) in the two prosodic conditions. (Adapted from Hirose 2020 with permission.)

conditions. The f0 peaks of the initial color words were significantly higher on average in the downstep than in the W2 rise condition. It can be considered anticipatory raising preceding downstepping elements (Rialland 2001) or the lowering of the word in the W2 rise condition before a planned rise. The genitive marker had a longer duration on average in the downstep than in the W2 rise condition. No durational difference between the two conditions was found in any other word.

2.1.2.2 Visual stimuli

All visual stimuli were identical to those used in Hirose (2020) (Experiment 2). Each visual display was divided into eight areas, each containing an object. Figure 1 presented an example visual scene. The eight objects included the LB target and the RB target, each corresponding to the LB or the RB interpretation of the audio stimuli. There were also LB and RB distractors mimicking the design of LB and RB targets but featuring different animals with the same colors as the targets. The presence of such objects with the same colors should establish a contrastive relationship with each of the LB and RB targets. Other objects were unrelated fillers, one of which had the same color mentioned by the audio sentence to serve as an additional color distractor. The positions of the different object types were balanced across items.

2.1.3 Procedure

Participants sat in front of a Tobii 1750 eye-tracker. After the participant fixated on the fixation cross, the visual display appeared on the screen. There was a 2500 ms delay between the presentation of the visual stimuli and the onset of the spoken stimuli to allow participants to scan all eight objects. To respond to the sentence they heard, children were instructed to select an object by pointing with a stick, and the experimenter made the click input for them (the accuracy of response times was, thus, compromised). Participants' eye movements were recorded from the onset of the audio stimuli until the click at a sampling rate of 50Hz.

Each participant listened to all 12 experimental sentences, six in the downstep condition and six in the W2 pitch rise condition, arranged into two counterbalanced lists. The presentation order was varied in each list and arranged such that no two experimental items were presented in a row.

2.2 Data analysis and results

2.2.1 Final target selection responses

There were two alternative visual objects in this experiment, either of which could be considered the correct target (LB target or RB target), among the eight objects in the scene. The percentage of erroneous choices (fillers and LB and RB competitors, i.e., any choice other than the LB or RB targets) by four-year-olds and three-year-olds was 1.3% and 5.25%, respectively. None of the participants made more than two erroneous choices in the 12 experimental trials. This shows that the participants in all groups were largely capable of handling the task of choosing one of the legitimate targets while eliminating six illegitimate candidates in response to the audio-linguistic stimuli. The erroneous cases were removed from the data. The children chose RB and LB targets at least once, instead of sticking to the same interpretation of the experiment.

Participants' final clicking responses for each group were then analyzed in a generalized linear mixed model (GLM). The dependent variable was the binary target choice, where LB and RB target choices are coded as 0 and 1, respectively. The fixed factor was the prosodic manipulation (prosody), where W2 pitch rise and downstep conditions are effects coded before being centered. Participants and items were considered random factors. The final model was selected through backward selection to achieve the simplest possible model while ensuring comparable explanatory power with the maximal random effects structure. Figure 3 shows the percentages of the LB and RB binary target choices on each condition in each group.

GLM analyses were conducted separately for the three- and four-year-olds and for both age groups combined, with the LB or RB binary choice as DV, where both the prosody and age in months (scaled) were considered as fixed factors. Notably, the four-year-olds exhibited a response bias toward RB (as shown by the intercept

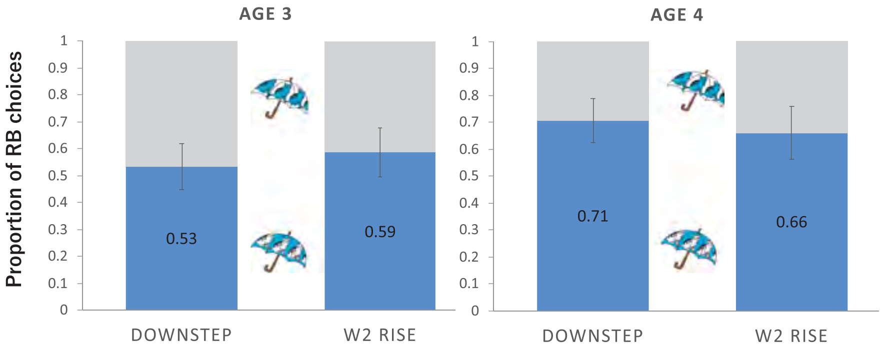

Figure 3: Proportion of RB and LB binary choices based on the subject means for each age group in the two prosodic conditions with 95% CI bars (shaded areas are for RB and unshaded areas for LB).

significantly greater than zero, $z = 3.913$, $p < .001$). Across-age group comparisons, with age group (age in years) as a fixed factor, revealed that the four-year-olds had a reliably stronger RB bias than the three-year-olds (the effect of age group: $z = -2.168$, $p < .05$). Three-year-olds showed an overall lack of the LB/RB response bias (intercept for three-year-old group: $z = 1.272$, $p > 0.1$). As far as the final object selection was concerned, the prosodic manipulation had no reliable impact for either age group of children (effect of prosody for the three-year-old group: $z = 1.226$, $p > 0.1$, Four-year-old group: $z = -0.953$, $p > 0.1$), and there was no interaction between the prosodic manipulation and age in months ($z = 1.362$, $p > 0.1$). The lack of a prosodic effect in four-year-olds is not consistent with what is suggested by the eye-movement data reported below.

2.2.2 Eye-tracking data

The eye-movement data analysis mainly examined participants' gaze bias between the LB and RB targets over time. First, the gaze data were broken down into discrete 100 ms time windows (1–100 ms, 101–200 ms etc.), which contained up to five sampling points. This way, the impact of tracking loss is minimized while allowing sufficiently detailed detection of the time course of the eye-gaze pattern. The first-time window started from the offset of the second word (e.g., *ne'ko*), where the prosodic manipulation (downstep vs. W2 pitch rise) becomes distinct but before further information (as to whether the pitch rise is followed by post-focal reduction) was available. For each of the visual targets (LB and RB targets), the number of gazes was summed for each window to calculate the logged ratio between the sum of gazes on the left-branching target over the sum of gazes on the right-branching target. It is referred to as log-ratio, representing the gaze bias score (Jincho, Oishi, and Mazuka 2019). In this experiment, the log-ratio of the positive value shows a bias toward the LB target, while that of the negative value shows a bias toward the RB target. Zero indicates that participants considered alternative targets to the same extent in the given time window.

The final goal of the eye-movement analysis was to see whether the gaze bias between the two alternative targets was affected by the prosodic manipulation (W2 pitch rise), while the participant was listening to a sentence, where an effect type may also be subject to change at different stages of development. The exact time course of these possible effects in different age groups, therefore, cannot be predicted. For this reason, our eye-movement analyses took two steps. The first analysis aimed to identify reliable time intervals informative of the prosodic effect in an objective way, as opposed to the researchers' subjective choice of the time windows. The second set of analyses used linear mixed-effect models to probe the prosodic effect on the log-ratio (gaze bias between the two branching targets), considering participant and item random factors.

For the first stage (identifying the time intervals for analyses), we used the non-parametric permutation-based test (Maris and Oostenveld 2007), which is a bottom-up approach adopted in visual world paradigm studies with Japanese-speaking child populations (Hirose and Mazuka 2017; Jincho et al. 2019). We followed the same procedure used by Hirose and Mazuka (2017), which is also similar to that employed by Jincho et al. (2019), to identify the time interval in which the effect of conditional manipulation was reliable on an objective ground.

Once the relevant time intervals to inspect were decided, linear mixed-effect models (LME, using the lme4 package in R) were utilized to analyze the log-ratio (expressing the fixation bias between LB and RB targets), with the prosodic manipulation as a fixed factor. The random factors included participants and items. The model with the maximal random structure was first considered, and the final model was selected via a backward selection procedure among converging models.

2.2.2.1 Three-year-olds

Figure 4 shows the proportion of fixation on each visual object. No reliable difference between the two prosodic conditions can be inferred from the outcome: the permutation-based analysis identified no cluster of time windows, suggesting the prosody effect.

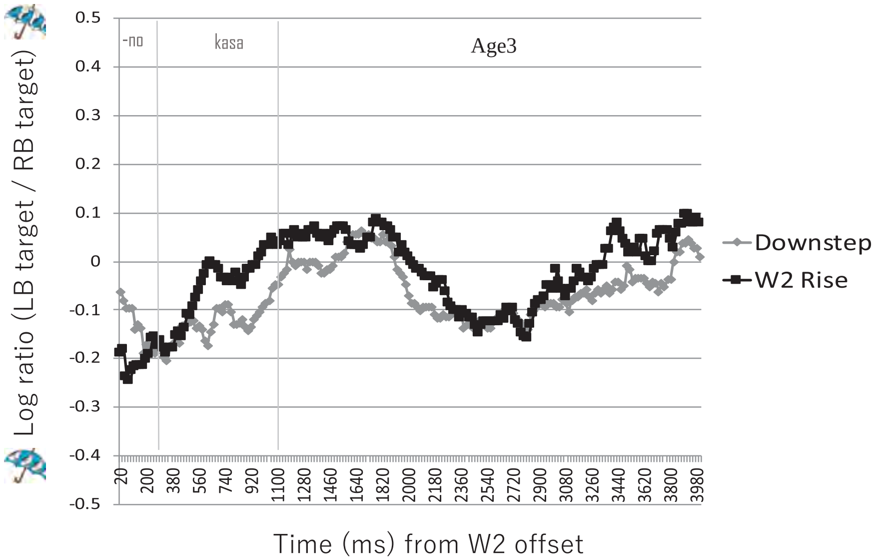

Figure 4: Plotted log-ratio in downstep and W2 rise conditions for 0–4000 ms for three-year-olds.

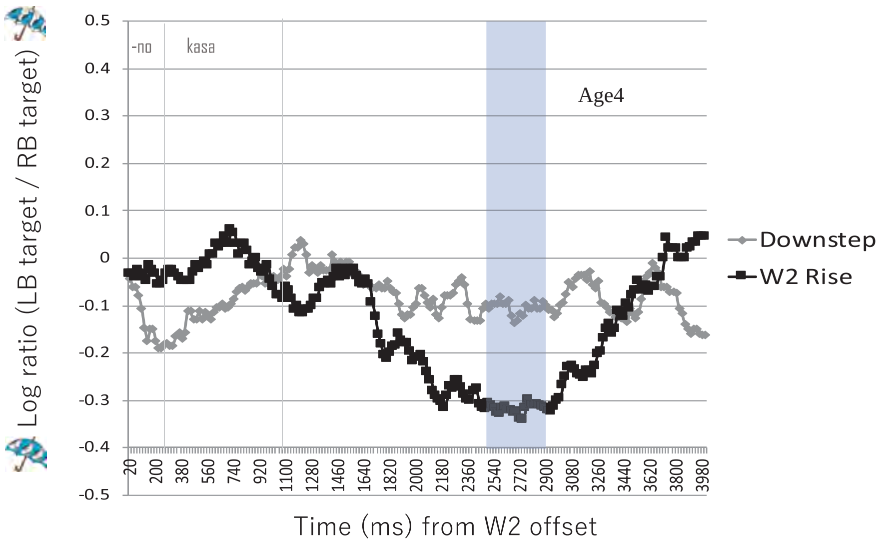

Figure 5: Plotted log-ratio in downstep and W2 rise conditions for 0–4000 ms for Four-year-olds. The shaded area (2500–2900 ms) indicates the time interval identified by the permutation-based analysis.

2.2.2.2 Four-year-olds

The log-ratio graph in Figure 5 suggests an overall bias for the RB target, relative to the LB target after the entire NP has been heard. This bias was enhanced with the W2 rise: The permutation-based analysis detected a 2500–2900 ms time interval (the shaded graph area) where the W2 rise condition led to a reliably larger RB bias than the downstep condition. The timing roughly coincided with when the participants made their clicking responses as they decided between the LB and RB targets. The LME analysis conducted for the time interval confirmed that the bias for the RB target increased with W2 rise ($\beta = -0.182$, $SE = 0.091$, $t = -2.00$, $p < .05$), where the selected model included the participant random slope with the participant and item intercept.

We ran two further LME analyses separately per the final target choice, where the selected models had the same random effect structure as the analysis above on all participants. The effect of prosody remained reliable ($\beta = -0.232$, $SE = 0.102$, $t = -2.28$, $p < .05$) for the subset of the data where the RB target was selected. The prosodic effect was not observed, and there was no reversed trend when the final choice was the LB target ($\beta = -0.1124$, $SE = 0.108$, $t = -1.04$, $p > .05$). Thus, the observed prosodic effect on the gaze bias toward the RB target led to more RB choices in the final interpretation. Meanwhile, the transient bias toward the opposite direction (the LB) among adult participants in the prior study did not show up in the eye-movement data in this study.

2.3 General discussion

2.3.1 Processing bias in the branching ambiguity across groups

Among the four-year-old group is an overall processing bias toward RB in the Adjective + NP-GEN + NP structure processing in the final target choice and the gaze bias between the LB and RB targets. These findings run counter to most processing models' presumption of a locality advantage. Moreover, the RB bias is not in line with the standard assumption of a phonology-syntax interface in Japanese, where the RB structure is considered a marked construction requiring some phonological demarcation, whereas the LB structure is accompanied by default prosody (Kubozono 1988).

For adults, the LB structure would still have an advantage in online sentence comprehension as it can be achieved by assigning most local structural positions to the incoming input as a sentence unfolds. However, young children, with a limited capacity for rapid incremental processing, may not enjoy the locality advantage as much as adults. Their processing choices may be more influenced by the ease with which certain structures are constructed or understood, such as the operational ease associated with Pot-Merge (Greenfield 1991; Fujita 2017), which corresponds to the RB structure here, relative to Sub-Merge, which in this case matches the LB structure. We have less reason to believe the observed RB bias comes from four-year-olds' inability to construct any hierarchical structure across the board, considering the children's sensitivity to the prosodic manipulation when they were selecting the target, which was revealed by the eye-tracking data. That is, the four-year-olds interpreted the f0 rise on the second word as a realization of a syntax-sensitive prosodic cue (e.g., metrical boost), indicating that the children had already constructed an RB structure.

Such a processing bias was not observed in the three-year-olds. All participants chose each of the different structure types at least once, instead of persisting with one interpretation and applying it to all trials. However, we found no consistent pattern for the group as a whole. The young participants could perform the complex task, choosing one target among eight objects, thereby making few erroneous responses. Even so, we have no solid evidence that the successful choice meant success in constructing the relevant syntactic structure for real-time comprehension. This issue warrants investigation further.

2.3.2 Interpretation of the pitch prominence

The main finding of the prosodic manipulation is again from the four-year-old children. In this group, the W2 pitch rise increased looks to the RB targets relative to looks to the LB targets not in the middle of processing the complex NP but at the stage when the participants are about to make the clicking choice. It makes sense if the W2 rise is interpreted as a metrical boost because it would only be relevant once RB syntax becomes a possibility (i.e., not until the second noun, e.g., *ka'sa* "umbrella"). The finding suggests that children at age four can construct both branching structures and recognize the appropriate prosodic pattern to demarcate the RB syntax during processing.

The lack of a prosodic effect in the three-year-old group makes it difficult to reach a definitive conclusion as to whether they did not recognize the prosodic difference or had yet to learn how the distinct prosodic patterns correspond to the two branching structures. However, alternatively, they could have been making random choices between the two probable enough options (where a cat and an umbrella both have at least some blue color) without really building the appropriate hierarchical structure, in which case the prosodic manipulation would not be relevant. This age group would need to be tested with a less demanding task for further investigation. It may also be worth checking the possibility that the younger population is more sensitive to the effect of relative plausibility between the two alternatives (e.g., a blue umbrella vs. a blue cat), although they understood the objects mentioned to refer to illustrations of the creature.

3 Conclusions

Some outcomes of this experiment provided informative answers to our original questions; others remain inconclusive. Positive conclusions are as follows. First, the processing bias for the branching ambiguity was different between adults and young children. At age four, the overall bias was toward the RB structure, which is considered marked and goes against the locality advantage in adult sentence processing. With the advantage of rapid online sentence comprehension put aside, the RB analysis is readily available and more favored by four-year-olds.

Second, the interpretation of the prosodic information was also different in four-year-old children in that they allowed for only a single interpretation of the prosodic signal, unlike adults (Hirose 2020). The eye-tracking experiment demonstrated that the W2 rise increased looks to the RB target relative to the LB target, suggesting that RB syntax-marking prosodic information (e.g., metrical boost) can be appreciated by children at age four. With such knowledge, young children can construct an RB hierarchical NP, thereby lessening the likelihood of the possibility that they arrived at the interpretation through a non-hierarchical analysis.

Third, the above-mentioned overall RB bias (enhanced by the W2 pitch rise) of the four-year-olds was not observed among the three-year-old population. In a future study, we intend to test these younger children with a simpler task (with a simpler visual scene) to at least eliminate the possibility that the participants were engaged in tasks other than linguistic processing.

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Chapter 14
Exceptive constructions in Japanese

1 Introduction

Exceptives are constructions that express exclusion, as in (1). They typically comprise an EXCEPTIVE PHRASE, which excludes the EXCEPTION from the domain of an ASSOCIATE. In (1), *everyone* is the associate, *except Mary* is the exceptive phrase, and *Mary* is the exception. An EXCEPTIVE MARKER usually introduces the exception. In English, this can include *except, but, besides,* and *except for*.

(1)	Everyone	laughed	[except/but/besides/except for	Mary]
	ASSOCIATE		EXCEPTIVE MARKER	EXCEPTION
			[. . . EXCEPTIVE PHRASE	. . .]

Moltmann (1995), von Fintel (1993), Kleiber (2005), García Álvarez (2008), Gajewski (2008, 2013), Crnič (2018), and Galal (2019) provide explicit semantic characteristics of exceptive constructions, describing how they differ from restriction, addition, reservation, opposition, and concession. We follow them in identifying the range of constructions to investigate. It is also vital to separate constructions specifically dedicated to expressing exclusion from those that express exception as a corollary, particularly, focus constructions with *only*, as in (2), where the exceptive reading is an inference.

(2) Only Mary laughed.

Beyond the cited references, the literature on exceptives is quite small, focusing largely on the construction's semantics, getting the right interpretation and inferences (Hoeksema 1987, 1995; Keenan and Stavi 1986; von Fintel 1993; Moltmann 1995; Lappin 1996; Zuber 1998; Peters and Westerståhl 2006; Gajewski 2008; García Álvarez 2008; Hirsch 2016). There is little syntactic work and no typological studies

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(Reinhart 1991; Sava 2009; O'Neill 2011; Pérez-Jiménez and Moreno-Quibén 2012; Soltan 2016; Potsdam and Polinsky 2017, 2019; Potsdam 2018a, 2018b, 2019; Al-Bataineh 2021). In syntactic work, one can address the following questions: how are exceptives expressed grammatically? Do some exceptives involve ellipsis of some kind to account for their interpretation?

This chapter seeks to fill some of these gaps by examining syntactic properties of the exceptive construction in Japanese, marked by the exponent *igai*, whose grammatical status we explore in section 4.1. While the main thrust of this chapter lies with the general description of Japanese exceptives, we hope for this discussion to stimulate experimental studies informed by our hypotheses; at several points in the chapter, we highlight possible experimental studies. In pursuing a syntactic description and analysis of Japanese exceptive constructions, we note the difference between connected and free exceptives, which are of interest to semanticists and syntacticians alike, and focus on the choice between the phrasal and clausal foundation of free exceptives. These issues inform the structure of the chapter. Section 2 introduces the difference between connected and free exceptive constructions. Section 3 presents diagnostics designed to determine whether Japanese free exceptives are underlyingly phrasal or clausal. Section 4 discusses the derivation of free exceptives. Section 5 addresses several outstanding issues raised by the proposed analysis. Finally, section 6 briefly lists exceptive impostors: constructions that can convey the meaning of exclusion to a generalization as an inference, similar to the example in (2).

2 Connected and free exceptives

As with the English *besides,* which can introduce exceptions, *igai* has two core meanings: additive and subtractive/exceptive. An example of the additive meaning of *igai* is given below:[1]

(3) 私は英語以外にロシア語を話せる。

Watashsi-wa	eigo-igai-ni	roshiago-o	hanas-e-ru.
1SG-TOP	English-except-NI	Russian-ACC	speak-able-PRS

"Besides English, I can speak Russian."

The ambiguity between additive and exclusion readings of exceptive markers seems to be common cross-linguistically (Sevi 2008; Vostrikova 2019) and certainly

1 Abbreviations follow the Leipzig Glossing Rules.

deserves a separate investigation, but we will not pursue it here. In what follows, we will concentrate only on the exceptive function of *igai*.

The consensus understanding of exceptives, based on the earliest semantic work (Hoeksema 1987, 1995), recognizes a distinction between FREE and CONNECTED exceptives, which refers to the surface position of the exceptive phrase regarding the associate. In connected exceptives, the associate and the exceptive phrase are adjacent and form a syntactic constituent, (4a).[2] In a free exceptive, it is the reverse (4b).

(4) a. 昨日はヒロ以外(の−*は)すべての男の子が来た。
Kinoo-wa [Hiro-igai(-no/*wa) subete-no otokonoko-ga]
yesterday-TOP H-except-GEN-TOP all-GEN boy-NOM
ki-ta.
come-PST
"Yesterday, every boy except Hiro came."

b. ヒロ以外(は/*の)昨日はすべての男の子が来た。
Hiro-igai(-wa/*no) kinoo-wa subete-no otokonoko-ga]
H-except-GEN-TOP yesterday-TOP all-GEN boy-NOM
ki-ta.
come-PST
"Yesterday, every boy came, except Hiro."

As the examples indicate, connected and free exceptives differ in their marking. Although both types are introduced by *igai,* the left-peripheral free exceptive phrase can be marked by the topic particle *wa* and cannot co-occur with the particle *no*;[3] for the connected exceptive (4a), only *no* is possible. Several properties distinguish connected exceptives from free exceptives; Table 1 shows the main characteristics.

As we consider Japanese exceptives marked by *igai,* at least two of the properties in this table deserve special consideration. Regarding Property 2, Japanese does not line up as neatly as the more familiar English or Spanish where this property has been considered. By subtracting from the domain of a quantifier, connected exceptives are claimed to be subject to the Quantifier Constraint (QC) in (5) (Hoeksema 1987, von Fintel 1993, Moltmann 1995), which restricts this quantifier to

2 Brackets indicate what elements constitute the subject.

3 Characterizations of *no* differ per its distribution and also on research sources. It is often described as the genitive marker, which is how we represent it in the glosses. However, its functions seem to be broader than that of the genitive. In our discussion, we refer to it as a particle. Nothing hinges on this characterization for the purposes of this study.

being a universal or negative universal, (6). Free exceptives are not restricted by the QC. The main clause need only be a generalization, which can admit exceptions, as in (7).

Table 1: Differences between connected and free exceptives.

Property		Connected exceptive	Free exceptive
1	Semantics	Subtracts from the domain of a quantifier	Expresses an exception to a generalization
2	Associate types	Certain quantified noun phrases only (universals)	XPs in general statements
3	Syntactic relation in clause	Nominal modifier	Clausal modifier
4	Position in clause	Adjacent to associate	Clause-peripheral or in parenthetical position
5	Constituency	Forms a constituent with the associate	Not a constituent with the associate
6	Category of exception	Nominal only	Not restricted to nominals
7	Realization of associate	Must be syntactically realized	May be implicit

(5) *Quantifier Constraint* (Moltmann 1995: 227)
The NP that an exceptive phrase [in a connected exceptive] associates with must denote a universal or negative universal quantifier.

(6) a. *Every boy/All boys/No boy* except John came.
b. **Few boys/Most boys/Three boys/At least three boys/The boys/Boys* except John came.

(7) a. *Few* know that Colorado produces wine, except visitors.
b. *The judges* gave her a standing ovation, except Simon Cowell.

However, in Japanese, connected exceptives are possible with non-universal quantifiers:

(8) タロウ以外の{ほとんど/沢山/(少なくとも)三人}の男の子が来た。
Taroo-igai-no {hotondo/takusan/(sukunakutomo) san-nin}-no otokonoko-ga]
T-except-GEN most/many/at least three-CLF-GEN boy-NOM
ki-ta.
come-PST
"Most/(At least) three boys except Taro came."

These examples indicate that the constraint on universal quantifiers in the associate is too strong. It accords with the considerations by García Álvarez (2008: 13–21) and Galal (2019) who indicate that in English, apparent connected exceptives may also violate the QC. All these data indicate that more semantic explorations into the nature of the QC generalization are needed.

(9) a. Salvias are native to most continents except Australia.
b. There was little furniture except our big fridge in the corner of the living room.
c. English policemen, except the guards who protect the royal family, do not carry guns.

Property 7 is the other characteristic where Japanese exceptives differ from the more familiar English ones. Assuming only free exceptives are clause-peripheral (see Property 4), excluding the ones with parenthetical intonation, all clause-internal exceptives should be of the connected type, appearing with an explicit associate because the exceptive phrase must have a syntactic constituent to modify. However, it is not the case. In (10, 11), there is no overt associate.[4,5]

(10) タロウはリンゴ以外(を)食べた。

Taroo-wa	ringo-igai(-o)	tabeta.
T-TOP	apple-except-ACC	ate

"Taro ate everything except the apple."

(11) 納豆は日本で以外あまり見かけない。

Nattoo-wa	nihon-de-igai	amari	mikake-nai.
natto-TOP	Japan-in-except	much	see-NEG.PRS

"Except Japan, we do not see matto much anywhere."

We will return to these examples in section 5.3 after we have examined the difference between clausal and phrasal exceptives, to which we now turn.

4 It seems speakers vary on whether the accusative case marker *o* can be dropped in (10). For many of the Japanese speakers consulted, omitting *o* in sentences such as (10) does not seem to affect their grammaticality.
5 It seems that speakers vary on whether having *de* before *igai* in (11) is acceptable. While some speakers note that the sequence *de-igai* is degraded, most of the Japanese speakers consulted found this word order to be well-formed.

3 Clausal and phrasal exceptives

While the free versus connected exceptive distinction is important, it is only part of the picture. In expanding the descriptive space for the cross-linguistic investigation, another additional parameter of variation is important: phrasal versus clausal exceptives. This distinction has received far less attention in the literature because it is primarily syntactic and not semantic. Initial appearances may suggest that an exception such as *Mary* in *Everyone left, except* ***Mary*** is simply a noun phrase (NP); however, work on Egyptian Arabic (Soltan 2016), English, Russian, Tahitian, Malagasy (Potsdam 2018a, 2019; Potsdam and Polinsky 2017; 2019), and Spanish (Pérez-Jiménez and Moreno-Quibén 2012) suggests that exceptions may contain a hidden clausal structure reduced by an ellipsis. In a PHRASAL EXCEPTIVE, the exception is a direct phrasal complement to the exceptive marker, (12a). However, in a CLAUSAL EXCEPTIVE, the exception is part of a larger constituent that is clausal (12b). Material within this clause may have been deleted, giving the appearance of a smaller constituent (a suggestion first made in Harris 1982).

(12) a. Nobody left, [except [Mary]$_{NP}$] PHRASAL EXCEPTIVE
b. Nobody left, [except [Mary ~~left~~]$_{CP}$] CLAUSAL EXCEPTIVE

Phrasal and clausal exceptives may co-occur in the same language and may be marked in formally distinct ways, as is the case in Russian (Oskolskaya 2014; Potsdam and Polinsky 2019). However, it is also possible that the surface realization of an exceptive construction may not be telling enough to determine its underlying syntax.[6] Regarding free exceptives in Japanese, one could imagine two possible scenarios, corresponding to (12a) and (12b) respectively. On the phrasal scenario, the exception is a simple nominal and the exceptive phrase is optionally marked by the topic particle *wa*.[7]

6 It is instructive to draw parallels between the exceptive and comparative constructions. In phrasal comparatives, the complement of *than* is a single phrase, typically a determiner phrase (DP), whereas in clausal comparatives, the complement of *than* is a clause (often with ellipsis). The ellipsis of clausal material in a clausal comparative makes it indistinguishable from the phrasal one on the surface, and special diagnostics are needed to tell them apart (cf. Bresnan 1973; Bhatt & Takahashi 2011).

(i) a. John is older [than [Mary]$_{DP}$] PHRASAL EXCEPTIVE
b. John is older [than [Mary ~~is~~]$_{CP}$] CLAUSAL EXCEPTIVE

7 The hypothesis remains neutral on whether the exceptive phrase originates inside the quantified associate and moves to the clause-initial position or whether the it is base-generated in the initial position.

(13) *phrasal analysis of Japanese free exceptives*

Mearii-igai(-wa)	paati-ni minna(-ga)	ki-ta.
Mary-except-TOP	party-to all-NOM]	come-PST

“Except Mary, everyone came to the party.”

In the clausal scenario, the associate and the expression of exception do not form a constituent at any level of representation. They start in separate clauses, and some of the identical material is deleted under ellipsis:[8]

(14) *phrasal analysis of Japanese free exceptives*

[[Mearii~~-ga~~	**~~paati-ni~~**	**~~ki-ta]~~**	**igai](-wa)**	minna(-ga)	paati-ni
Mary-NOM	party-to	come-PST	except-TOP	all-NOM]	party-to
ki-ta.					
come-PST					

“Except Mary, everyone came to the party.”

In either derivation, the surface form of the free exceptive is the same. Diagnostics distinguishing phrasal and clausal exceptives are needed to decide between these two approaches. We summarize the core ones in Table 2. The list presented here is not exhaustive but sufficient to identify the category of the constituent introduced by *igai* and will allow us to compare Japanese with other languages whose exceptives have been studied. It also allows for concentrating on some diagnostics that are less clear-cut or have not been studied extensively, in particular, D3 and D7.

Table 2: Diagnostics differentiating between phrasal and clausal exceptives.

		PHRASAL EXCEPTIVE	CLAUSAL EXCEPTIVE
1	Exception can be a full clause	no	yes
2	Multiple exceptions	no	yes
3	Fixed form of nominal exception	yes	no
4	Clausal/speaker-oriented adverbs	no	yes
5	Separate binding domains	no	yes
6	Ambiguity in sluicing	no	yes
7	Internal reading with “same, different”	yes	no

8 In such cases, a particular issue must do with the change in polarity between the two clauses, which is necessary for identity of the elided material and the material in the antecedent. We will return to this issue in section 5.2.

Diagnostic 1: The most straightforward diagnostic is that clausal exceptives allow full expression of the missing clausal material, as in (15), while this is impossible in phrasal exceptives.

(15) They did not invite anyone, except they invited Mary.

In Japanese free exceptives (an entire clause with the exception in it) can be expressed:

(16) メアリーを招待した以外は彼らは女の子を招待しなかった。
Mearii-o shoutaishi-ta-igai-wa karera-wa onnanoko-o
Mary-ACC invite-PST-except-TOP they-TOP girl-ACC
shoutaishi-nakat-ta.
invite-NEG-PST
"They did not invite any girls, except they invited Mary."

(17) タロウが英語を話せる以外は誰も外国語を話せません。
Taroo-ga eigo-o hanas-e-ru-igai-wa
Taro-NOM they-ACC speak-can-PRS-except-TOP
daremo gaikokugo-o hanas-e-mas-en.
nobody foreign.language-ACC speak-can-POLITE-NEG
"No one speaks a foreign language, except that Taro speaks English."

Such data point to a clausal analysis of Japanese free exceptives.

Diagnostic 2: Clausal exceptives allow for multiple exceptions, which do not form a single constituent, while phrasal exceptives do not. We discuss the mechanism by which exceptions might escape the clausal ellipsis below; however, the contrast follows from the reasonable assumption that this mechanism is iterative, while the exceptive marker in phrasal exceptives cannot select multiple complements.

(18) Every boy danced with every girl, except [John] [with Mary].

Multiple exceptions are grammatical although dispreferred in Japanese free exceptives. We hypothesize that this dispreference may stem from processing factors; because of the rigidly head-final nature of Japanese, the free exceptive must precede the clause stating the generalization, and holding several exceptions that must be linked to associates in working memory may cause discomfort. Further research can test to see whether this explanation is correct.

(19) ジョンを田中先生に以外(は)昨日は全ての学生を全ての先生に紹介できた。
[Jyon-o] [Tanaka-sensei-ni]-igai(-wa) kinoo-wa
John-ACC Tanaka-teacher-DAT-except-TOP yesterday-TOP
[subete-no gakusei]-o [subete-no sensei]-ni syookai-deki-ta.
all-GEN student-ACC all-GEN teacher-DAT introduce-able-PST
"No one speaks a foreign language, except that Taro speaks English."

Additionally, an anonymous reviewer notes a contrast in grammaticality when different case markers are used in free exceptives. As shown here, pronouncing accusative and dative case markers on the respective NPs does not affect the grammaticality of a sentence. However, the use of the nominative marker is marginal at best. For example, (14) is heavily degraded if *Mary* appears with a nominative case marker. We hypothesize that it has to do with the difference in the information-structure import of *ga* vs *wa*. In root clauses, the former is used to mark backgrounded information and is commonly found in thetic clauses (Kuroda 1972). Such encoding is incompatible with the contrastive interpretation expected of an exception. Further, the structure we propose in (42b) below involves topicalization of the exception, which calls for *wa*, not *ga*.

Diagnostic 3: The exception in a clausal exceptive can be non-nominal, while that in a phrasal exceptive must be nominal. The possibility of a non-nominal exception follows if the mechanism that allows the exception to avoid ellipsis is insensitive to the category of the exception. However, with phrasal exceptives, the exceptive marker selects only nominal complements. This contrast obtains in Japanese. In Japanese connected exceptives, which we believe are phrasal, the exception is always nominal and is incompatible with a postposition, (20). In free exceptives, a postposition is possible, preceding or following *igai* [we set aside interpretive differences between examples such as (21a) and (21b)].[9]

(20) 納豆は日本(*で)以外(で)の国であまり見かけない。
Nattoo-wa nihon-(*de-)igai(-de)-no kuni-de amari mikake-nai.
natto-TOP Japan-in-except-in-GEN country-in much see-NEG.PRS
"We don't see natto much in countries other than Japan."

9 See section 4 for structural differences between the two orders of postposition and exceptive marker.

(21) a. 日本以外（は）納豆はどの国でもあまり見かけない。
Nihon-igai(-wa) nattoo-wa donokunidemo amari mikake-nai.
Japan-except(-TOP) natto-TOP any.country much see-NEG.PRS
b. 日本で以外（は）納豆はどの国でもあまり見かけない。
Nihon-de-igai(-wa) nattoo-wa donokunidemo amari mikake-nai.
Japan-in-except(-TOP) natto-TOP any.country much see-NEG.PRS
c. 日本以外で?（は）納豆はどの国でもあまり見かけない。
Nihon-igai-de-?(wa) nattoo-wa donokunidemo amari
Japan-except-in(-TOP) natto-TOP any.country much
mikake-nai.
see-NEG.PRS
"Except Japan, we don't see natto much in any country."

Diagnostic 4:[10] Clausal exceptives allow for a clause-level adverb in the exception, as in (22), while phrasal exceptives do not, as in (23).[11] The basis for this diagnostic is the assumption that temporal adverbs and speaker-oriented adverbs require a clause to modify and cannot modify nominals.

(22) a. I was able to meet everyone, except *regrettably/unfortunately/sadly* Mary.
b. I will go to any party, except yours *tomorrow*.
c. The workers always eat here, except Juan *on Mondays*.

(23) a. *Everyone except *regrettably* Mary came to the party.
b. *No party except yours *on Tuesday* was attended by the mayor.

In Japanese, the contrast between connected and free exceptives is observed with modal and speaker-oriented adverbs. Consider the following pair:

10 This diagnostic is developed and applied in Pérez-Jiménez and Moreno-Quibén (2012), Soltan (2016), and Vostrikova (2021).
11 Examples such as (23) must be read without parenthetical intonation that would allow for a clausal structure.

(24) a. ハナコ以外の全ての女の子が知っている限り/多分パーティーに来ます。
Hanako-igai-no subete-no onnanoko-ga
H-except-GEN all-GEN girl-NOM
sitteirukagiri/tabun paati-ni ki-mas-u.
based.on.my.knowledge/perhaps party-to come-POLITE-PRS
"Based on my knowledge/Possibly, all girls except Hanako will come to the party."
NOT: "Except, based on my knowledge/possibly, Hanako, all girls will come to the party."

b. ハナコ以外は知っている限り/多分パーティーに全ての女の子が来ます。
Hanako-igai-wa sitteirukagiri/tabun paati-ni
H-except-TOP based.on.my.knowledge/perhaps party-to
subete-no onnanoko-ga ki-mas-u.
all-GEN girl-NOM come-POLITE-PRS
"Based on my knowledge/Possibly, all girls except Hanako will come to the party."
% "Except, based on my knowledge/possibly, Hanako, all girls will come to the party."[12]

In (24a), a connected exceptive, the adverbials "based on my knowledge" and "perhaps, possibly" necessarily scope over the entire clause. In (24b), the scope of the adverbial is ambiguous; it can be interpreted as scoping over the entire clause or just over the negative entailment that Hanako will not come. This latter interpretation suggests that the adverb is enclosed only under one clause (with material deleted) and not associated with the main clause (thus, the elided material is indicated with < >):

(25) [Hanako-igai-wa sitteirukagiri/tabun <. . .>] paati-ni subete-no
H-except-TOP based.on.my.knowledge/perhaps party-to all-GEN
onnanoko-ga ki-mas-u.
girl-NOM come-POLITE-PRS
"Except, based on my knowledge/possibly, Hanako, all girls will come to the party."

12 Not all the speakers we consulted get the reading where the tense phrase (TP) adverbial scopes just over the exception. Further work is needed to understand what may cause cross-speaker variation.

The two canonical positions of clausal adverbs are right before and after the subject (Koizumi and Tamaoka 2010). Assuming such positions, the two readings of the example with a free exceptive result from a structural ambiguity in which there are two clauses: the adverb may be interpreted either within the exceptive clause or the main clause expressing the generalization (all the girls will come to the party). The two placements should be distinguishable by prosodic contours, an issue we leave for further research. Crucial for our purposes is the fact that the connected exceptive does not show ambiguity in the scope of clausal adverbials because there is only a single clause.

Diagnostic 5: Assuming a free exceptive is clausal, each of the linked clauses constitutes its local binding domain. In that case, binding can be found in one of the clauses but not in both, as in the following English example; the corresponding connected exceptive is ungrammatical because multiple exceptives are impossible (see D2).

(26) a. Nobody made any gains for anyone, except John for himself. CLAUSAL
b. *Nobody except John for himself made any gains for anyone. PHRASAL

Japanese free exceptives also show separate binding domains:

(27) ハナコが自分のこと以外は誰も何も心配していない。
Hanako-ga zibun-no-koto-igai-wa] [daremo nanimo
H-NOM self-GEN-thing-except-TOP [nobody anything
sinpai-shite-i-nai].
worry-do-PRS-NEG.PRS
"Except for Hanako about herself, nobody is worried about anything else."

Diagnostic 6: A diagnostic based on Sluicing is developed by Stockwell and Wong (2020) (initially noted in Merchant 2001: 22). The authors observe that an example, as in (28), is ambiguous. In (28a), the content of the missing material is supplied by the entire first clause, including the exceptive phrase, serving as the antecedent. The interpretation in (28b) is mysterious, as the required antecedent *John liked the movie* is absent. Stockwell and Wong (2020) argues that this interpretation is available because the exceptive contains a hidden clausal structure, as in (29), which supplies the needed antecedent.

(28) Nobody liked the movie, except John, but I don't know why. CLAUSAL
a. but I don't know why <nobody liked the movie except John>.
b. but I don't know why <John liked the movie>.

(29) Nobody liked the movie, except John ~~liked the movie~~, but I don't know why.

Phrasal exceptives in English do not allow for the second reading, as the antecedent needed for reading (30b) is simply not available.

(30) Nobody except John liked the movie, but I don't know why. PHRASALS
  a. but I don't know why <nobody except John liked the movie>.
  b. *but I don't know why <John didn't like the movie>.

The situation in Japanese is more nuanced. Consider the following example with a free exceptive:

(31) タロウ以外は会議でみんな怒っていたけど、何故か（は）解らない。

Taroo-igai-wa	kaigi-de	minna	okot-te	ta-kedo,
T-except-TOP	meeting-at	all	get.upset-GER	PST-CONJ

nazeka(-wa)	wakar-anai.
why(-TOP)	understand-NEG.PRS

"Except Taro, everyone was upset during the meeting, but I don't understand why."

Assuming the underlying clausal structure in a free exceptive, we should expect two readings: (i) the speaker does not know why everyone except Taro was upset, and (ii) the speaker does not know why Taro was not upset. However, most Japanese speakers we consulted only accept reading (i). It is not entirely clear why reading (ii) is not available, and examples such as (31) add a new dimension to the investigation of sluicing and related phenomena in Japanese.

At this point, we would like to offer a couple of considerations. First, it is possible that reading (ii) is blocked because of the nature of the deletion in the sluiced clause. Thus, to anticipate our discussion in section 4, the exceptive clause is nominalized, which may preclude the necessary identity required to license ellipsis in sluicing. That alone does not constitute an explanation but adds more complexity to the already murky issue of clausal ellipsis in Japanese (Merchant 2001: 84–85; Yoshida, Nakao, and Ortega-Santos 2014). It is not clear if nominalized clauses can antecede sluicing in Japanese (Masaya Yoshida, p.c.). Second, another possible explanation has to do with the insufficient context supplied by the construction in (31), something that could be ascertained in an experimental study; however, the question still arises as to how exactly English and Japanese free exceptives differ per the sluicing diagnostic.

Diagnostic 7: The richness of context regarding D6 also plays a significant role in the last diagnostic: ambiguity of the interpretation with the words *different* or *same* (based on Beck 2000). These words can have discourse-anaphoric and reciprocal-like readings, as illustrated in (32). We term them as external and internal readings (Beck 2000 calls them discourse-anaphoric and Q-bound readings).

(32) Every student reads a different book.
a. Every student reads a book that is different from a salient book in the discourse. EXTERNAL READING
b. Every student reads a book that is different from the one that any other student reads INTERNAL READING

This ambiguity can serve as a diagnostic for clausal exceptives. Phrasal, not clausal, exceptives, allow for internal reading:

(33) a. Every student reads a different book. AMBIGUOUS
b. Every student reads a different book, except Mary. EXTERNAL READING ONLY
c. Every student except Mary reads a different book. AMBIGUOUS

The reason that the internal reading is not available in the clausal exceptive can be seen by looking at the non-elliptical version in (34). The exceptive clause *Mary didn't read a different book* has only an external reading, as there is no quantifier to trigger the Q-bound reading.

(34) Every student reads a different book, except Mary doesn't read a different book.

If this contrast is genuine, then it provides us with a way to probe the internal structure of exceptives in languages that allow for similar ambiguity for the words *different* or *same.* In Japanese, the word 違う *tigau* "different" allows for the same ambiguity.

(35) 全ての学生が違う本を読んだ。
Subete-no gakusei-ga tigau hon-o yon-da.
all-GEN student-NOM different book-ACC read-PST
"Every student reads a different book"

a. Every student reads a book that is different from the salient one in the discourse. EXTERNAL READING
b. Every student reads a book that is different from the one any other student reads. INTERNAL READINGS

In applying the diagnostic to Japanese exceptives, we find no contrast between connected and free exceptives:

(36) a. タロウ以外の全ての学生が違う本を読んだ。

Taroo-igai-no	subete-no	gakusei-ga	tigau	hon-o
T-except-GEN	all-GEN	student-NOM	different	book-ACC

yon-da.
read-PST
"Every student except Taro reads a different book."

b. タロウ以外は全ての学生が違う本を読んだ。

Taroo-igai-wa	subete-no	gakusei-ga	tigau	hon-o
T-except-TOP	all-GEN	student-NOM	different	book-ACC

yon-da.
read-PST
"Except Taro, every student reads a different book."

Although the two readings seem clear, native speakers of English and Japanese vary in discerning them, even with sufficient context provided. A cursory survey of several English and Japanese speakers suggests that some do not accept internal reading at all. Regarding Japanese, several speakers found (36a) and (36b) alike in that they both call only for external reading. Some speakers of both languages accepted the internal reading for both free and connected exceptives, including those contexts where the external reading was contextually ruled out. This result calls for closer scrutiny into the diagnostic and may invite future experimental work on separating the external and internal readings regarding exceptives.

We have identified several clear differences between free and connected exceptives in Japanese, which suggest that the former are clausal in nature. We have also identified areas of diagnostic uncertainty, which may highlight the weakness of certain diagnostics or the need for further study, including experimental investigations. Assuming Japanese free exceptives are clausal, the next question regards the way they are derived. We turn to this issue in the next section.

4 Derivation of Japanese free exceptives

Section 3 argued that free exceptives in Japanese have clausal origins followed by an ellipsis, as sketched in (12b). To recapitulate, evidence in favor of this analysis comes from the availability of a full clause in free exceptives; multiple exceptions that do not form a constituent; non-nominal exceptions; separate binding domains; and the availability of clausal adverbs scoping exclusively over the exception. In this section, we explore the details of the Japanese derivation and compare it to the clausal analysis of English free exceptives (Potsdam and Polinsky 2019). We begin with discussing the categorial status of the exceptive marker *igai.*

4.1 Categorial status of igai

以外 *igai* "outside," along with the similarly structured 以内 "inside," was borrowed from the Chinese, possibly in the Han period. Both words are built on the verb 以 (cf. Djamouri, Paul, and Whitman 2013). Martin (1975: 113) describes *igai* rather cryptically as a restrictive particle. Categorially, it could be a conjunction, a (relational) noun, or a postposition. The inventory of conjunctions in Japanese is quite slim, and, in any case, they do not co-occur with *wa*, which rules out that characterization.

We already brought up parallels between exceptive and comparative constructions; the comparative marker in Japanese is characterized as a relational noun (Sudo 2015), which raises the possibility that *igai* is similarly a noun. However, *igai* cannot occur on its own, which is unexpected of nouns:[13]

13 A reviewer notes that there is one context in which *igai* can occur alone, which is in an "echo" context, as in (i):

(i) A: ええと、タロウ以外は...
Eeto Taroo-igai-wa . . .
well T-except-TOP
"Well, except Taro . . ."

B: 以外は？
Igai-wa?
except-TOP
"Except what?"

For any other occurrences of *igai*, they must be accompanied by some complement that denotes an exception.

(37) a. *以外は？
*Igai-wa?
except-TOP
(“What about others?”)
b. 他は？
Hoka-wa?
except-TOP
“What about others?”

Further, *igai* can combine with NPs, such as *koto* “thing,” without any linking material, as is typical of Japanese postpositions (e.g., Kuno 1973: 213–220):

(38) タロウが来ること以外は聞いていない。
Taroo-ga kuru-koto-igai-wa kii-te-nai.
T-NOM come-*koto*-except-TOP hear-GER-NEG.PRS
“I was not informed about anything except that Taro is coming.”

Stacking is another characteristic typical of Japanese postpositions (Kuno 1973: 108–111; Shibatani 1977; Sadakane and Koizumi 1995), and *igai* can stack with other postpositions, as in example (21c), where it co-occurs with *de.* These considerations point to the status of *igai* as a postposition. Thus, it should combine with an NP, though we have already presented evidence that Japanese free exceptives contain a clausal layer. These findings can be reconciled by positing a nominal layer above the clausal layer.

4.2 Evidence for the nominal layer in free exceptives

A nominal layer above the clausal one is not unique to the exceptive constructions in Japanese; it has been proposed for comparatives (Sudo 2015 and references therein) and all kinds of temporal and conditional clauses (Kuno 1973; Tsujimura 1992; Horie 1997). The initial evidence in favor of the external nominal layer above the clausal structure stems from examples such as (38), where the overt nominal *koto* appears. Additional evidence in favor of the nominal layer stems from the use of adnominal inflection in exceptives. Some predicates take different forms in finite (copular) and adnominal positions (cf. Miyagawa 1987), for example,

(39) a. デザインがとても簡素{だ/*な}。
Dezain-ga totemo kanso{-da/*-na}.
design-NOM very simple-COP/ADN
“The design is very simple.”

b. タロウ以外は全ての学生が違う本を読んだ。
totemo kanso{*-da/-na} dezain-ga
very simple-COP/ADN design-NOM
"a very simple design"

In exceptive constructions, only the adnominal form can be used, which indicates that an NP precedes *igai* even when it is not expressed overtly:

(40) デザインがとても簡素{*だ/な}以外は文句の付けどころがない。
Dezain-ga totemo kanso{-da/*-na}-igai-wa
design-NOM very simple-COP/ADN-except-TOP
monku.no.tuke.dokoro-ga nai.
place.to.complain.about-NOM NEG.PRS
"Except for the design being very simple, there is nothing to complain about."

If this is on the right track, we can characterize *igai* uniformly as a postposition that combines with an NP. The head of that NP may (but does not have to) be spelled out (see Tsujimura 1992; Horie 1997 on the optionality of final heads in Japanese nominalizations). In free exceptives, such an NP includes a nominalized complementizer phrase (CP), thus: $[_{PP}$ $[_{NP}$ $[_{CP}$ . . . .] (*koto*)] *igai*].

A possible consideration against this proposal comes from the lack of the nominative-genitive conversion (NGC), also known as *ga-no* conversion: a phenomenon where the nominative and genitive of a subject can alternate in a prenominal clause (Harada 1971; Hiraiwa 2001; Maki and Uchibori 2008; Ochi 2017). Commonly observed in relative clauses, NGC is not available in exceptives:

(41) タロウ{が/*の}その本を読んだ以外誰も何も読まなかった
[Taroo-ga/*-no sono hon-o yon-da]-igai(-wa)
T-NOM/-GEN that book-ACC read-PST-except- TOP
daremo nanimo yom-anakkat-ta.
anyone anything read-NEG-PST
"Except for Taro reading that book, no one read anything."

However, it has been argued on independent grounds that first, relative clauses are TPs, not CPs (Murasugi 1991—but see Kaplan and Whitman 1995 for the CP analysis of Japanese relative clauses), and, second, NGC is available only in TPs (Hale 2002, Miyagawa 2013). On the assumption that exceptive clauses are CPs, we do not expect to find NGC in them (an alternative may appeal to the fact that the exception in (41) is a clause, thus the whole clause has been fronted to the exception position, presumably spec,CP. In that position, the clausal subject is inaccessible for conversion which requires access to the subject from outside the CP).

4.3 Analytical details

Free exceptives in Japanese are derived via the attachment of the postpositional phrase headed by *igai* to a clause that expresses the generalization. To illustrate, we present the derivation for the following sentence, similar to (4b) above; in the schematics below, we use English glosses only.

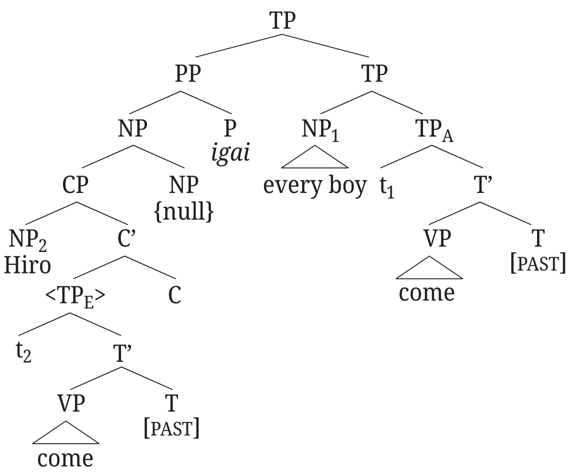
(42) a. ヒロ以外(は)すべての男の子が来た。

Hiro-igai(-wa) subete-no otokonoko-ga ki-ta.

H-except-TOP all-GEN boy-NOM come-PST

"Except Hiro, every boy came."

b.



The antecedent clause in (42), *every boy came*, is TP_A, and the associate of the exception undergoes quantifier raising (although it is not clear whether it is a crucial part of an exceptive derivation). The exceptive phrase is a postpositional phrase (PP) adjoined to TP_A, where the postposition *igai* selects an NP (with the null noun head in this case). This NP includes a CP, where the exception, *Hiro*, has moved to spec,C, and the remainder (TP_E) undergoes deletion under identity with the antecedent clause TP_A. The exceptive PP can also appear in a topic phrase (not shown in the derivation). As multiple topics are allowed in Japanese, free exceptives and clausal adverbials can appear in alternate orders:

(43) a. ヒロ以外は昨日はすべての男の子が来た。

Hiro-igai-wa	kinoo-wa	subete-no	otokonoko-ga	ki-ta.
H-except-TOP	yesterday-TOP	all-GEN	boy-NOM	come-PST

b. 昨日はヒロ以外はすべての男の子が来た。

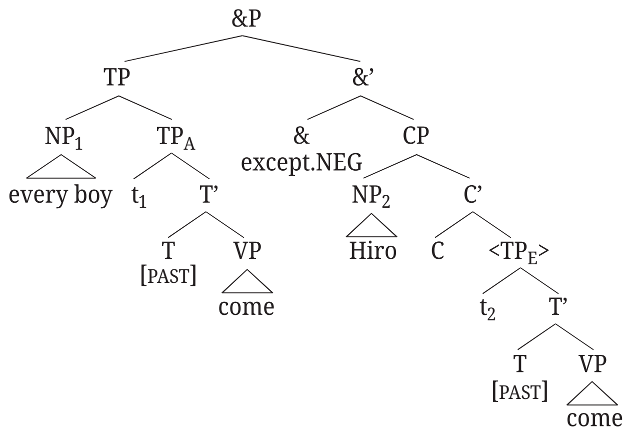
Kinoo-wa	Hiro-igai-wa	subete-no	otokonoko-ga	ki-ta.
yesterday-TOP	H-except-TOP	all-GEN	boy-NOM	come-PST

"Except Hiro, yesterday every boy came."

Positional alternations between free exceptives and other clause-peripheral material suggest that the occurrence in the first position of the left periphery is not a critical property of Japanese free exceptives. Consider now the derivation of a clausal free exceptive in English (Potsdam and Polinsky 2019):[14]

(44) a. Every boy came, except Hiro.

b.



In English, *except* is a coordinating conjunction that heads an &P, coordinating the main clause *Every boy came* and the exceptive clause, *except Hiro*. The antecedent clause *Every boy came* is TP_A and the associate of the exception undergoes quantifier raising (although it is not clear whether it is a crucial part of an exceptive derivation). The exceptive phrase comprises the exceptive marker and a clause, TP_E, out of which the exception has moved. For concreteness, we show the exception moving to spec,CP. Finally, the exceptive clause, TP_E, is deleted under identity with the antecedent clause, TP_A.

14 We represent the exceptive conjunction as including covert negation, allowing for the identity of polarity in the antecedent and elided clauses. Section 5.2 discusses issues of polarity in-depth.

If we now compare the derivation of Japanese free exceptives to that of English ones, headedness aside, the main differences lie in the nature of the exceptive marker (a postposition in Japanese, a coordinating conjunction in English) and the presence of the nominal layer above the exceptive clause CP (*yes* in Japanese, *no* in English). A reason for the difference between the two languages may lie in the impoverished inventory of Japanese conjunctions; in their absence, other means of clause linking can be used.

5 Outstanding issues

Assuming a PF deletion analysis in the derivation of free exceptives in Japanese, as in (42b), we face several outstanding issues, such as (i) the nature of the complementizer in the CP embedded under *igai*, and (ii) issues of identity under ellipsis. We discuss them in sections 5.1 and 5.2. Other outstanding issues that arise outside of the ellipsis analysis have to do with silent associates in connected exceptives and the relation between exceptives and negation.

5.1 Nature of the head in the embedded complementizer phrase

We analyze the clause embedded under the nominalizing head in the *igai*-postpositional phrase as a CP for two reasons, both of them indirect. First, the exception, the remnant that survives clausal ellipsis, is arguably A-bar moved and contrastively focused. Such material appears in the CP area (e.g., Rizzi 1997; Erteschik-Shir 2007). However, the A-bar movement proposal is particularly hard to defend given the lack of clear island effects in Japanese (Fukui 2006; Lasnik and Saito 1992; Omaki et al. 2020; Richards 2000; Watanabe 2003), let alone the lack of overt wh-movement.

Second, we contrasted Japanese exceptive clauses with relative clauses; the latter are, arguably, TPs in Japanese and allow for GNC. By that logic, the former are larger in structure, hence CPs. It would be desirable to identify other evidence in favor of the CP analysis. It is also important to understand the nature of the silent complementizer C that is present in the exceptive clause. This head attracts the expression of exception to its specifier. Following Lobeck (1995) and Merchant (2001), we assume this head carries the feature [E], which licenses the non-pronunciation of its complement. Given that exceptions are not wh-words, the nature of the C head is unclear and remains an issue for future investigation.

A silent C has also been proposed in some clausal analyses of Japanese comparatives (Bhatt and Takahashi 2011; see Sudo 2015 for the proposal that these clauses include an underlying relative clause only). It remains to be seen if the underlying C in these clauses, which then undergo ellipsis, is the same or different in nature.

5.2 Identity under ellipsis

Since the earliest studies on ellipsis, a recurring issue has been the form of the identity requirement that must hold between an elided element and its antecedent (see Lipták 2015 and Ranero 2021 for a summary and references). Early analyses (Chomsky 1964, 1965; Ross 1967; Sag 1976; Williams 1977) required strict syntactic identity, while later ones turned to a purely semantic identity requirement (Dalrymple, Shieber, and Pereira 1991; Hardt 1993, 1999; Merchant 2001). Recent work has returned to a purely syntactic account or a mixed account in which both semantic and some amount of syntactic identity is required (Chung, Ladusaw, and McCloskey 2011; Merchant 2013; Lipták 2015; Barros and Vicente 2016; Thoms 2015; Ranero 2021).

In exceptives, the issue of identity arises regarding polarity mismatch. Exceptives require that the elided clause and the antecedent have opposite polarity, as in (45). It can be seen in the interpretation of the exceptives in (46), where the polarities of the overt and elided clauses are opposite.

(45) *Polarity Generalization* (following García Álvarez 2008: 129)
The proposition expressed in the main clause and exceptive clause must have opposite polarity.

(46) a. Every student succeeded, except Bill ~~**didn't** succeed~~.
b. I **didn't** see anyone, except Bill ~~I saw~~.

Three possible solutions emerge, and we will sketch them out briefly. Assuming syntactic identity on ellipsis, the polarity reversal may be only apparent, and the exceptive phrase contains a possibly covert instance of negation that triggers the reversal, for example, embedded in the meaning of the exceptive marker (Potsdam 2019; Soltan 2016). In some languages, such as Malagasy, the negative component of the exceptive marker is morphologically overt (Potsdam 2019). In this approach, the negation is not actually inside the ellipsis site and there is no polarity mismatch. If so, (47a) is analyzed along the lines of (47b); we represented such negation in the structure of the English example in (44b).

(47) a. Every student succeeded, except Bill.
b. Every student succeeded, AND.NOT Bill ~~succeeded~~.

Extending this idea to Japanese, the lexical specification of *igai* includes negation, making it similar to a caritive postposition ("without"). A possible consideration against this approach has to do with the non-polarity reversing (additive) meaning of *igai*, as illustrated in (3); it has two different meanings. It is still possible to imagine two different lexical items, one with negation in it ("apart from; not included in") and the other without one (the additive marker), but it is striking that such co-occurrence of meanings is cross-linguistically common, hence non-accidental (Zuber 1998; Sevi 2008; Vostrikova 2019).

Another way of tackling polarity mismatches while maintaining syntactic identity relies on featural (under)specification (Ranero 2021). The main constraint on identity is realized via the presence (absence) of features. However, instead of a simple featural identity, the syntactic condition on the ellipsis relies on features being non-distinct. For example, a privative feature present in the antecedent but not in the ellipsis site (or vice-versa) does not constitute a violation of identity. Nor is a functional projection present in one but not in the other.

In this approach, clauses containing negation project a ΣP phrase where the head Σ hosts a [NEG] feature (Laka 1990, 1991). Conversely, ΣP is absent in affirmative clauses (Laka 1990, 1991). Adopting this analysis, exceptives involve a mismatch between the absence and presence of a head bearing a feature bundle; in this case, $\Sigma_{[+NEG]}$. The affirmative clause is featurally empty regarding $\Sigma_{[+NEG],}$ hence no feature clash is observed, and an ellipsis is possible (modified from Ranero 2021: 188):

(48) Antecedent: [$_{XP}$ . . . YP] no Σ^0
Ellipsis site: [$_{\Sigma P}$ [$_{XP}$ . . . YP]] $\Sigma^0{}_{[+NEG]}$

Finally, another strand of explanation for the Polarity Generalization is that such mismatches are generally allowed in clausal ellipsis, and syntactic conditions on ellipsis are just too restrictive. Kroll (2019) documents several sluicing contexts in which the sluiced clause and its antecedent mismatch in polarity. In (49), the antecedent is positive, while the sluiced clause is negative.

(49) Either the Board grants the license by December 15 or it explains why ~~it **didn't** grant the license by December 15~~. (Kroll 2019: 25)

Kroll (2019, 2020) offers a discourse-pragmatic analysis of the identity condition in the clausal ellipsis that allow for such mismatches. However, it remains to be seen how to save this approach from overgeneration whereby more mismatches may be allowed than actually possible. Identity conditions on deletion in clausal exceptives may not be uniform for all exceptive clauses. For instance, the (covert) negation approach may work for exceptive markers that do not have the additive reading, and the featural non-distinctness may be more applicable to structures with markers such as the Japanese *igai* or English *besides.* We leave the choice of a specific approach to identity for further research.

5.3 Missing associate

In Section 2, we already introduced a possible challenge concerning the contrast between connected and free exceptives regarding the implicit nature of the associate. Based on English, several researchers propose that the associate can only be implicit in free exceptives (presumably regardless of their phrasal or clausal derivation).

The situation in Japanese is more complicated. First, only the left periphery is available for exceptive placement, and as discussed in Section 4.3, optional scrambling of free exceptives is also possible. Thus, this diagnostic in and of itself is not very strong. Second, case markers, the topic marker *wa*, and the linker *no* can be dropped under several conditions (Kuno 1973; Fry 2003; Fujii and Ono 2000). Hence, the status of the exception expression is not always clear. It is further confounded by some graded judgments we will review below. We start by reviewing some of the examples with an unexpressed associate.

(50) そのデザートはタロウ以外が食べる。
Sono dezaato-wa Taroo-igai-ga taberu.
this dessert-TOP T-except-NOM eat.PRS
"Everybody except Taro eats this dessert."

(51) タロウはリンゴ以外(を)食べた。
Taroo-wa ringo-igai(-o) tabe-ta.
T-top apple-except-ACC eat-PST
"Taro ate everything except the apple."

The two examples show exception phrases in the nominative and accusative, respectively. It is independently established that the topic marker *-wa* cannot immediately follow case markers (Watanabe 2009); that is, a case marker and the topic marker cannot co-occur:

(52) a. タロウはリンゴ以外を(*は)食べた。

Taroo-wa	ringo-igai-o-(*wa)	tabe-ta.
T-TOP	apple-except-ACC-TOP	eat-PST

b. タロウはリンゴ以外(*を)は食べた。

Taroo-wa	ringo-igai-(*o-)wa	tabe-ta.
T-TOP	apple-except-ACC-TOP	eat-PST

"Taro ate everything but the apple."

Given the scrambling options discussed earlier, we can identify (52b) as an instance of a free exceptive with an implicit associate, an option widely attested in free exceptives. Though we do not have instrumental measures to support it, the prosody of (52b) includes breaks after each topic-marked phrase, and the pitch after the exception expression does not go down, which accords with observations on the prosody of topic expressions in Japanese (Nakanishi 2001). Meanwhile (52a) does not include a prosodic break after the object and there is no pitch reset. An instrumental investigation of prosodic differences between examples such as (52a) and (52b) is called for. However, for now, we would like to propose that (52a) is an instance of a connected exceptive with a silent (null-pronominal) associate, whereas (52b) is a genuine free exceptive. As such, the two examples reflect two distinct types of "missing" associates. Given that the associate in the connected exceptive is expressed as a null pronominal, the linker *no* is deleted and the case marker directly follows *igai*.

(53)

[[ringo-igai-~~no~~]	*pro*]-o
apple-except-GEN	*pro*-ACC

If this analysis is correct, we can also predict that postpositions, as with case markers, can follow *igai* in connected exceptives with the null associate. This prediction is confirmed:

(54) タロウはハナコ以外からチョコレートをもらった。

Taroo-wa	Hanako-igai(-*pro*)-kara	chokoleetto-o	moratta.
T-top	H-except-from	chocolate-ACC	receive.PST

"Taro received chocolate from everyone except from Hanako."

Unlike case-marked exceptives, where the order "case-marker-before-*igai*" is simply unavailable, postpositions can appear either after the exceptive marker, as in (54), or before it:

(55) タロウはハナコ以外からチョコレートをもらった。
Taroo-wa Hanako-kara-igai chokoleetto-o moratta.
T-top H-from-except chocolate-ACC receive.PST
"Taro received chocolate from everyone except from Hanako."

The difference, as we contend, again boils down to the difference between connected and free exceptives; in (54), there is a null-pronominal associate in a connected exceptive, marked off by the postposition. In (55), the postposition *igai* stacks on the postposition *kara* forming an exceptive phrase. Table 3 summarizes the distributional properties of Japanese exceptives with a missing associate. The linear order of the exceptive marker and postpositions or case markers partially resolves the structural ambiguity in the two types of associates.[15]

Table 3: Japanese exceptives with unexpressed associate.

	Free exceptive with implicit associate	**Connected exceptive with null associate**
Case marker	impossible	follows *igai*
Postposition	precedes *igai*	follows *igai*

The next question that arises has to do with the licensing conditions on null associates in the connected exceptive. Null associates in exceptive phrases have been reported for other languages, Arabic in particular (Al-Bataineh 2021), but, crucially, in Arabic, the null associate is licensed by negation. In Japanese, as shown by the examples, null associates can also be licensed in affirmative clauses.

Another outstanding issue raised by the data regards language processing. Given structural ambiguity between free exceptives with implicit associates and connected exceptives with null associates, how is this ambiguity reflected in real-time? This question could inform a future experimental study where the two orders of postposition and *igai*, such as (54) and (55), could be compared systematically.

15 The marker *ni* has been subject to much discussion in the literature on Japanese, with ongoing debates about its status as a case marker or a postposition (e.g., Sadakane & Koizumi 1995). Its distribution in exceptives can be used as an additional argument in favor of its status as a postposition, as it can precede or follow *igai*.

6 Exceptive or exceptive impostor?

The discussion thus far has been limited to *igai*, but other particles in Japanese have been claimed to express an exceptive meaning, in particular, the focus particles *dake* and *shika*, both of which correspond to the English "only" or "just." Both have been traditionally analyzed as focus particles denoting exclusion, hence the parallels with the English *only*.

Researchers seem to converge on the conception that *dake* should be analyzed as a general focus particle (see Futagi 2004 and references therein). Further, *dake* can combine with *shika* and *igai*, which also suggests that its function is different from that of the exceptive marker. We can, therefore, set *dake* aside as a generalized focus particle whose meaning of exclusion arises via inference. As for *shika*, things are a bit more complicated. One of the key properties that distinguish *shika* from *dake* is its sensitivity to polarity. That is, *shika* requires a clause-mate negative (suffix) *na*(*kat*) as its licensor, as in (56).

(56) a. タロウしか来なかった。
Taroo-shika ko-nakat-ta.
T-only come-NEG-PST
"Only Taro came."
b. *タロウしか来た。
Taroo-shika ki-ta.
T-only come-PST

However, as in the English paraphrase, we see no semantic input of this negation in the resulting sentence meaning: despite being a negative suffix on the verb, (56a) roughly has the same meaning as exceptive examples without negation. It raises the question as to how the meaning of a sentence containing *shika* is derived compositionally, and, further, whether the traditional assumption that *shika* is an exclusive particle should be maintained. We address these questions by comparing the semantic properties of *shika* and *igai*.

In comparing *shika* and *igai*, let us start with similarities, which have to do with the ability to antecede coreferential pronouns. To illustrate, the examples below, adapted from Kuno (1999), describe the same situation: nobody except Taro was wearing a seatbelt, which is why only Taro survived. When *Taro* is marked with the particle *dake*, the null pronoun in the following sentence cannot pick out the other individuals that are part of the exclusive meaning (i.e., it cannot mean "they"), as shown in (57b). It is consistent with the status of *dake* as a regular focus particle. However, when *Taro* appears with either *shika* or *igai*, the null pronoun in the subsequent sentence cannot pick out Taro as its referent. Thus, its referent is restricted to "they," cf. (58a) and (59a).

(57) a. タロウだけが助かった。シートベルトをしていたからだ。
Taroo-dake-ga tasukat-ta. *pro* siitoberuto-o si-tei-ta-kara-da.
T-only-NOM survive-PST seatbelt-ACC wear-GER-PST-COP
"Only Taro survived. That's because he was wearing a seatbelt."

b. タロウだけが助かった。シートベルトをしていなかったからだ。
Taroo-dake-ga tasukat-ta. #*pro* siitoberuto-o
T-only-NOM survive-PST seatbelt-ACC
si-tei-nakat-ta-kara-da.
wear-GER-NEG-PST-COP
"Only Taro survived. #That's because they were not wearing a seatbelt."

(58) a. タロウしか助からなかった。シートベルトをしていたからだ。
Taroo-shika tasukara-anakat-ta. # #*pro* siitoberuto-o
T-only survive-NEG-PST seatbelt-ACC
si-tei-ta-kara-da.
wear-GER-PST-COP
"Only Taro survived. #That's because he was wearing a seatbelt."

b. タロウしか助からなかった。シートベルトをしていなかったからだ。
Taroo-shika tasukara-anakat-ta. *pro* siitoberuto-o
T-only survive-NEG-PST seatbelt-ACC
si-tei-nakat-ta-kara-da.
wear-GER-NEG-PST-COP
"Only Taro survived. That's because they were not wearing a seatbelt."

(59) a. タロウ以外助からなかった。シートベルトをしていたからだ。
Taroo-igai tasukara-anakat-ta. # #*pro* siitoberuto-o
T-except survive-NEG-PST seatbelt-ACC
si-tei-ta-kara-da.
wear-GER-PST-COP
'Only Taro survived. #That's because he was wearing a seatbelt.'s

b. タロウ以外助からなかった。シートベルトをしていなかったからだ。
Taroo-igai tasukara-anakat-ta. *pro* siitoberuto-o
T-except survive-NEG-PST seatbelt-ACC
si-tei-nakat-ta-kara-da.
wear-GER-NEG-PST-COP
"Only Taro survived. That's because they were not wearing a seatbelt."

This difference in the possible referent of the null pronoun suggests that the *dake*-sentence in (57) regards Taro, while the *shika*-sentence and the *igai*-sentence regard the associate, not the exception. This notion is what motivates an analysis under which *shika*, just as *igai,* is analyzed as an exceptive marker. For example, Yoshimura (2007) proposes a universal exceptive marker analysis of *shika*: she contends that *shika* is an exceptive marker whose semantic representation includes a universal quantifier. Hence, under her analysis, *Only Taro survived* is not an accurate paraphrase of (56a). Instead, it should be paraphrased as *Everyone except Taro did not survive*. Now the meaning of (56a) can be derived compositionally, as the semantic input of negation is evident in its interpretation (*did **not** survive* for the non-exceptions vs. *survived* for the exception).

However, several significant differences separate *shika* and *igai*, which cast doubt on the view that *shika* is an exceptive marker. As discussed, *shika* is polarity-sensitive and requires a clause-mate negative suffix *na*(*kat*) as its licensor.[16] Meanwhile, Hasegawa (2010) observes that the negation licensing *shika* does not behave in the same way as ordinary negation. As shown below, the negation that co-occurs with *shika* cannot license the negative polarity item (NPI) *nanimo*, (60). It differs from the negation that co-occurs with *dake* and *igai*, which can license an NPI, as in (61) and (62).

(60) *タロウしか何も食べなかった。
*Taroo-shika nanimo tabe-nakat-ta.
*T-shika anything eat-NEG-PST

(61) タロウだけ何も食べなかった。
Taroo-dake nanimo tabe-nakat-ta.
T-only anything eat-NEG-PST
"Only Taro didn't eat anything."

(62) タロウ以外何も食べなかった。
Taroo-igai nanimo tabe-nakat-ta.
T-except anything eat-NEG-PST
"Except Taro, nobody ate anything." (lit.: . . . everyone did not eat anything)

16 However, exceptives marked by *igai* can occur with or without negation, and exceptives of this type are more common in affirmative clauses, something that may be lost in discussion of exceptive constructions in theoretical papers. In corpus counts based on the 1,000,000 sentence train-1 portion of the corpus ASPEC, approximately 88% of *igai*-exceptives are found in affirmative clauses.

Additionally, Hasegawa notes that, while the exceptive meaning that *Taro came* is cancelable in (64), the same information introduced by *shika* in (63) is not. It suggests that the exceptive meanings that *shika* and *igai* contribute are of different types (entailment/presupposition and implicature respectively; see also Ido and Kubota 2021).

(63) タロウしか来なかったし、タロウも来なかった。

#Taroo-shika	ko-nakkat-ta-shi,	Taroo-mo	ko-nakkat-ta.
T-shika	come-NEG-PST-and	T-also	come-NEG-PST

"Only Taro came, and Taro also didn't come."

(64) タロウ以外来なかったし、タロウも来なかった。

Taroo-igai	ko-nakkat-ta-shi,	Taroo-mo	ko-nakkat-ta.
T-except	come-NEG-PST-and	T-also	come-NEG-PST

"No one other than Taro came, and Taro also didn't come."

For these reasons, Hasegawa concludes that *shika* is not an exceptive marker, arguing in favor of the traditional view that *shika* is an exclusive particle. Following this conclusion, we also assume that *shika* is an exclusive particle, while *igai* is a genuine exceptive marker.

7 Conclusions

This chapter began by introducing exceptives as constructions that express exclusion. Thus, they comprise an exceptive phrase, which excludes the exception from the domain of an associate.

(65)

Everyone	laughed	[except	Mary]
ASSOCIATE		EXCEPTIVE MARKER	EXCEPTION
		[. . . EXCEPTIVE PHRASE	. . .]

We presented and analyzed the expression of exception in Japanese, formally marked with the postposition *igai.* As a postposition, *igai* combines with an NP. The internal structure of that NP can be quite complex; in particular, it can include a nominalized CP. Japanese allows for connected and exceptives, which differ by whether the exception and the associate form a constituent (*yes* for the former, *no* for the latter). We have shown that Japanese free exceptives always include underlying nominalized CPs (sometimes headed by a null nominal head), with elided material. This kind of ellipsis is different from clausal ellipsis in exceptives in languages like English, where no nominal or determiner head is attested. Until now, only two types of free exceptives have been recognized: non-clausal phrasal ones (unattested so far) and clausal (with ellipsis), as in English or Egyptian Arabic (Soltan 2016). Thus, the novel Japanese results enrich the existing typology of exceptive constructions by recognizing a nominalized CP as another source of exceptive constructions.

Among other languages whose exceptives have been studied, Japanese also stands out as the only language thus far where both free and connected exceptives can have a null associate, which does not have to be licensed by negation. On the one hand, given the proliferation of null nominals in Japanese, it is not unexpected that null associates in Japanese exceptives are readily available. However, the exact licensing conditions on these null expressions are not yet properly understood.

Finally, Japanese contributes novel data to the observation that the original constraint on universal quantifiers in the associate of an exceptive is too strong. García Álvarez (2008: 13–21) and Galal (2019) have already called it into question based on English data, and Japanese serves as another reminder that more semantic work is needed to understand the nature of the domain of generalization in exceptives.

While the main focus has been on the exceptive constructions with the postposition *igai*, which we consider a dedicated exceptive marker, we have also discussed the expression of exclusion with the particles *dake* and *shika*. Although these particles can mark off exclusion to a generalization, this appears to be a side effect of their semantics, not their dedicated function. Thus, they are not exclusive to exceptive constructions.

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